A HISTORY

OF

EUROPEAN THOUGHT

IN THE

NINETEENTH CENTURY

BY

JOHN THEODORE MERZ

VOL. I.

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PREFACE.

As the plan of this work is fully given in the Introduction, only a few points, chiefly of a personal character, remain to be touched on here.

The first refers to the motive which led me to a course of studies, extending over more than thirty years, of which this book is the outcome.

The object of the book is philosophical, in the sense now accepted by many and by divergent schools—*i.e.*, it desires to contribute something towards a unification of thought. When in the beginning of my philosophical studies I became convinced that this is the task of philosophy, I felt the necessity of making myself acquainted, at first hand, with the many trains of reasoning by which, in the separate domains of science, of practical and of individual thought, such a unification has been partially and successfully attempted. Such a survey seemed to me indispensable. The possession of a map showing the many lines of thought which our age has cultivated seemed to me the first requisite, the basis from which a more complete

unification would have to start. The following pages contain the result of this survey. Like every survey, it can claim to be merely an approximation. It gives outlines which closer scrutiny will have to correct and fill up.

My original intention was to complete this survey in three volumes, corresponding to the three divisions of the subject set out in the Introduction.

Some of my friends, who desired that the publication of the book should not be unduly delayed, considered that the Introduction and the earlier chapters of the work would give something intelligible in themselves, and urged the advantage of smaller volumes. I therefore decided to complete the first part of the history, which deals with scientific thought, in two volumes instead of in one.

For the information of my readers, I mention here that the two last chapters of this volume, which treat of the astronomical and of the atomic views of Nature, will be followed in the second volume by similar chapters on the mechanical, the physical, the biological, the statistical, and the psychophysical views of Nature, and that it is my intention to close the first part of my subject by an attempt to trace concisely the development of mathematical thought in this century.

My thanks are due to many friends who have supported me with assistance and encouragement.

I consider myself fortunate in having secured for the revision of the whole volume the invaluable aid of Mr Thomas Whittaker, B.A., whose profound erudition, know-

ledge of ancient and modern literature, and great editorial experience, were well known to my late friend Professor Croom Robertson, during his successful editorship of the first series of 'Mind.'

Mr S. Oliver Roberts, M.A., of the Merchant Taylors' School, has kindly read over the fourth, and Professor Phillips Bedson, of the Durham College of Science of this city, the last, chapter of this volume. The Introduction has greatly benefited by a thorough revision by my brother-in-law, Dr Spence Watson, a master of the English language.

I must also thank him and Dr Thomas Hodgkin for having given me what I value as much as assistance—namely, encouragement.

One indeed to whom I am in this respect more indebted, perhaps, than to any one else—whom to have known has meant, for many, a revelation of the power of mind and the reality of spirit—is no more: Ernst Curtius. While I was writing the last pages of this volume, in which he took a warm interest, the tidings arrived that he had passed away. But she who was nearest and dearest to him is still with us—a true priestess of the higher life, who has kept burning in the soul of many a youthful friend the spiritual fire when it was in danger of being quenched by the growing materialism of our age.

J. THEO. MERZ.

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INTRODUCTION.

I.

Thought, the hidden world 1

(BEHIND the panorama of external events and changes which history unfolds before our view there lies the hidden world of desires and motives, of passions and energies, which produced or accompanied them; behind the busy scenes of Life lie the inner regions of Thought. Only when facts and events cease to be unconnected, when they appear to us linked together according to some design and purpose, leading us back to some originating cause or forward to some defined end, can we speak of History in the sense which the word has acquired in modern language; and similarly do the hidden motives, desires, and energies which underlie or accompany the external events require to be somehow connected, to present themselves in some order and continuity, before we are able to grasp and record them.

That which has made facts and events capable of being chronicled and reviewed, that which underlies and connects them, that which must be reproduced by the historian who unfolds them to us, is the hidden element of Thought. Thought, and thought alone, be it as a principle of action or as the medium of after-contemplation, is capable of arranging and connecting, of combining what is isolated, of moving that which is stagnant, of propelling that which is stationary. Take away thought, and monotony becomes the order.

2. Thought, the only moving principle.

3. History of Nature, how to be understood.

This assertion may seem bold to many, who would look rather to the grand phenomena of Nature than to the narrow limits of man's activity. A few remarks will, however, suffice to show that my proposition is not opposed to the view which they take. It may be urged that, independent of human life altogether, the earth has a history, the planetary system has a development, and that, according to modern theories, evolution is the principle which governs inanimate as well as animated nature; that rest and sameness are nowhere to be found, everywhere change and unrest. But change and unrest do not necessarily constitute history. Motion and change would be as monotonous as absolute rest, were they merely to repeat themselves endlessly, did the whole movement not produce something more, and were this something more not greater or better than the beginning. But greater and better are terms which imply comparison by a thinking beholder, who attaches to one thing a greater value than to another, judging by certain ideal standards, which are not in the objects or process of nature themselves, but are contained only in his own think-

4. Not intelligible without intellect.

ing mind. It may be that a mechanical and mindless series of changes can produce numbers without end, or forms of countless variety: but this process would deserve the name of history only if either the transition from unity to multiplicity, or the production of formal variety, were capable of being understood by a thinking mind,—if the result of the process were a matter of some concern, if an interest were attached to it, if a gain or loss could be recorded. The pendulum which swings backwards and forwards in endless monotony, the planet which moves round the sun in unceasing repetition, the atom of matter which vibrates in the same path, have for us no interest beyond the mathematical formulæ which govern their motions, and which permit us mentally to reproduce, *i.e.*, to think them. A combination of an infinite number of these elementary movements would have as little interest, were it not that out of such a combination there resulted something novel and unforeseen: something that was beautiful to behold or useful to possess, something that was valuable to a thinking mind in a higher or lower meaning of the word.

But if, even in inanimate nature, the processes of change acquire an interest, possess a history, only if referred to a thinking mind which can record, understand, and appreciate them, how much more is this the case when we deal with human affairs, where man is not only the thinking beholder but the principal agent? Here the historic interest would cease, were the succeeding years and ages to produce no valuable change, were the rule of existence and the order of life to repeat themselves in unceasing monotony. The savage tribes of Africa have a history, but

5 History of savage tribes, what is it?

this history is all known when the order of the day, the year, at most of a generation, is known. Even the highly complicated but stagnant life of China would have a short historical record—many thousands of years taking up no more space than as many days of modern European history:

"Better fifty years of Europe than a cycle of Cathay."

6. Two ways in which Thought enters into History.

Thus it is that Thought becomes in two ways a subject of great interest and importance to the historian. Of every change in nature or human life we can ask: What has been its result in the world of thought? What gain or loss, what progress, has it worked in the minds of men, of us the beholders? Has it increased our knowledge, enriched our stock of ideas, deepened our insight, broadened our views and sympathies—in one word, has it added to our interests? has it made larger and fuller our inner life?

And of every change in human affairs we can ask this further question: What part has thought, the inner life, played in this change? These two questions mark the task of the historian of Thought.

7. Definition of Thought impossible.

I do not think it necessary or practicable at this stage to explain minutely the terms with which we have so far been dealing. Many a one might be tempted to ask for a definition of Thought, or for a preciser statement of the actual relation between Nature, Life, and Thought.[1]

[1] In refusing to define what I mean by Thought, I take up the opposite position to that occupied by Prof. Max Muller in his latest work, 'The Science of Thought,' London, 1887, p. 1, where he says: "I mean by Thought the act of thinking, and by thinking I mean no more than combining. I do not pretend that others have not the right of using Thought in any sense which they prefer, provided only that they will clearly define it." So far as definition is at all a part of the work of the historian, I maintain that it is the result and

Such definitions must be left to the reader himself, if in course of the perusal of these volumes he finds it necessary to form abstract theories on these points. Any definition given now would inevitably involve us in controversies, which would be embarrassing and confusing. I rely upon the general and undefined sense of the word Thought, assuming that every one will connect some intelligible meaning with it, some meaning which will enable him to understand the very general proposition with which we started, the existence of an inner or hidden world behind the world of external events and facts, the continually changing nature of this inner world, and the connection and reaction between the two worlds. Whether in time and in importance the outer or the inner world is the first, whether within the latter equal value attaches to the clearer province of Reason, *i.e.*, defined Thought, to the obscurer regions of Feeling and Imagination, and to the unconscious world of Impulse, these are questions which it is not necessary to answer at present. As it was enough to point to the existence of the two worlds of Life and Thought, so it will be enough to notice that thought does not mean merely defined, clear, methodical thought, but likewise the great region of desire, impulse, feeling, and imagination, all of which play, we must admit, a great part in the inner life of the soul as well as in that of the outer world.

8 Relation of outer and inner world undefined.

9. Many meanings of Thought

outcome of his narrative, the impression which he leaves on the mind of the reader when he has perused the work. History is not mainly a science which proceeds by analysis; it is the attempt to collect and arrange in a living picture an enormous mass of detail. Too rigid definitions, like lines which are too hard and marked, spoil the total effect.

In this sense of the word we have in the following treatise to deal with the History of Thought: not, however, with the history of thought in general, but with that of a defined period, with that of the present age and the age immediately preceding it,—the age, in fact, to which the writer and his readers belong, of which they have a personal knowledge and recollection more or less wide and intimate. It is the latter circumstance which has made me select this special portion of the history of thought; for it is that portion of which, it seems to me, I and my contemporaries should—if we go about it in the right way—know most. As every person is his own best biographer, so it seems to me every age is, in a certain sense, its own best historian.

10. Thought of the present age.

We know that this has been frequently denied so far as external events (that which many persons call history *par excellence*) are concerned. Contemporary writers do not, it is stated, get beyond mere records of events, records at once one-sided, incomplete, and confusing. It is indeed necessary to have the records in great number and variety: because the true and real record can only be given by him who combines all these many records into one, who avoids the errors arising from special points of view, from narrowness of outlook, from individual ignorance, blindness, or prejudice. Still, in spite of such defects, the contemporary records will always remain the most valuable sources for the future historian who may succeed in sifting their various testimonies, combining and utilising them to produce a fuller and more consistent picture of the bygone age. But while his work may be only temporarily valuable, theirs is

11. Contemporary history, to what extent possible and valuable.

lasting. It is hardly doubtful that, after hundreds or thousands of years have passed, the simple, detailed, and perhaps contradictory, narratives of contemporary witnesses will outlive those more elaborate and artistic efforts of the historian which are so largely inspired and coloured by the convictions of another—*viz.*, his own—age. For as Goethe has remarked: "History must from time to time be rewritten, not because many new facts have been discovered, but because new aspects come into view, because the participant in the progress of an age is led to standpoints from which the past can be regarded and judged in a novel manner."[1]

12 Supposed Objectivity of historians.

Most of the great historians whom our age has produced will, centuries hence, probably be more interesting as exhibiting special methods of research, special views on political, social, and literary progress, than as faithful and reliable chroniclers of events; and the objectivity on which some of them pride themselves will be looked upon not as freedom from but as unconsciousness on their part of the preconceived notions which have governed them. But where the facts recorded and the mind which records them both belong to the same age, we have a double testimony regarding that age. The events, and the contemplating mind, supplement each other to form a more complete picture, inasmuch as the matter and the medium through which it is viewed belong to the same time. And so it comes to pass that historians like Thucydides, Tacitus, and Machiavelli are looked upon as

[1] 'Materialien zur Geschichte der Farbenlehre,' Werke, 2te Abtheilung, Band 3, p 239 I quote from the new edition, brought out by the German Goethe Society.

perfect models in the art of writing history, and the memoirs of many modern statesmen are more lastingly valuable than the more elaborate and connected narratives of remote and secluded scholars.

13. Value of contemporary records, both of Facts and Thought.

But if the contemporary record of facts will always have a peculiar value, however incomplete it may be, still more must this be the case with the contemporary record of thought; especially if thought means the whole of the inner life of an age, not merely that portion which in the form of defined thought has been incorporated in the written literature of the age. For a large portion of this hidden life is known only to those who have taken part in it. The vague yearnings of thousands who never succeed either in satisfying or expressing them, the hundreds of failures which never become known, the numberless desires which live only in the hearts of men or are painted only in their living features, the uncounted strivings after solutions of practical problems dictated by ambition or by want, the many hours spent by labourers of science in unsuccessful attempts to solve the riddles of nature,—all these hidden and forgotten efforts form indeed the bulk of a nation's thought, of which only a small fraction comes to the surface, or shows itself in the literature, science, poetry, art, and practical achievements of the age. Equally important, though not equally prominent, this large body of forgotten thought has nevertheless been that which made the measure full, which heaped the fuel ready for the match to kindle; it constitutes the great propelling force which, stored up, awaits the time and aid of individual talent or genius to set it free. Philosophers tell us of

14. Mystery of the Life of Thought.

15. Latent Thought the material for genius.

the wastefulness of organic life, of the thousands of germs which perish, of the huge volume of seed scattered uselessly. A similar fate seems to fall on the larger portion of intellectual and moral effort, but here a deeper conviction tells us that it is not the sacrifice but the co-operation of the many which makes the few succeed, that excellence is the prize of united effort, that many must run so that one may reach a higher goal. What other feeling could console those legions of honest workers who spend their lives in trying to deal with the seemingly unconquerable host of social evils, the apparently growing vice and misery of large towns, who raise a cry for oppressed nationalities, or preach against the curses of war and militarism? Or what higher and unselfish satisfaction could an author derive from spending half a lifetime in producing a work which in the end may fall dead-born from the press, if it were not the conviction that in the cause in which he has failed another after him may succeed, and that his failure may be a portion of the silent and hidden efforts that co-operate towards a useful end?[1] But who in after-ages can write the history of this forgotten and hidden work of a nation? Whose historical sense is delicate enough to feel where the pressure was greatest and the effort longest ere the new life appeared, whose eye penetrating and discerning enough to follow up the dim streaks

[1] "Sehen wir nun während unseres Lebensganges dasjenige von anderen gelestet, wozu wir selbst früher einen Beruf fühlten, ihn aber, mit manchem andern, aufgeben mussten, dann tritt das schöne Gefühl ein, dass die Menschheit zusammen erst der wahre Mensch ist, und dass der Einzelne nur froh und glücklich sein kann, wenn er den Muth hat, sich im Ganzen zu fühlen."—Goethe, 'Wahrheit und Dichtung,' 9th Book; Werke, 27, 277.

16. Contemporary record of Thought more faithful.

of twilight, dazzled as he must be by the blaze of the risen sun? We who live in the expectation of the light which is to come, surrounded by the shadows, difficulties, and obstacles; we who belong to the army, and are not leaders, who live in, not after, the fight,—we claim to be better able to tell the tale of endless hopes and endeavours, of efforts common to many, of the hidden intellectual and moral work of our age.[1]

17 Events of the immediate past

How far back we who have lived during the second half of the present century may extend the period of which we claim to have a personal knowledge, is a point of further interest. Certain it is that in our parents and immediate forefathers we have known the representatives of a generation which witnessed and laboured in the interests of the great Anti-Slavery, the Reform, and the Anti-Corn-Law movements, who experienced the revolutions worked by the introduction of steam-power and gas, who took part in the great work of national and popular education abroad and in the reform of school-life in England. They themselves went through the enthusiasm of the anti-Napoleonic Revolution in Germany, came under the influence of Goethe's mature manhood, were fascinated by the stories from the pen of the Wizard of the North, par-

[1] Compare what A. de Tocqueville says, 'Œuv. comp.,' vol. VIII. p. 170: "Nous sommes encore trop près des événements pour en connaître les détails. Cela paraît singulier, mais est vrai. Les détails ne s'apprennent que par les révélations posthumes, contenues dans les Mémoires, et sont souvent ignorés des contemporains. Ce qu'ils savent mieux que la posterité, c'est le mouvement des esprits, les passions générales du temps, dont ils sentent encore les derniers frémissements dans leur esprit ou dans leur cœur; c'est le rapport vrai des principaux personnages et des principaux faits entre eux. Voilà ce que les voisins des temps racontés aperçoivent mieux que ne fait la postérité."

took of the spirit of the Romantic School, felt the electrical touch of Lord Byron's verse, listened to the great orators of the third French Revolution, and could tell us of the now forgotten spell which Napoleon I. exercised over millions of reluctant admirers. Most of these fascinations and interests live only in the narratives of contemporaries and surviving witnesses, few of whom have succeeded in perpetuating them with pen or brush, making them intelligible to a future age, most of them die with the generation itself Not only have we listened to their words and seen in their features the traces of the anxieties they lived through, in their eyes the reflected enthusiasms and aspirations, in their glances and in the trembling of their voices the last quiverings of bygone passion and joy,—we have received from them a still more eloquent testimonial, a more living inheritance. But this we cannot hand down to our children in the form in which it was given to us: it has not passed through our hands unaltered. This inheritance is the language which our parents have taught us. Unknowingly they have themselves altered the tongue, the words and sentences, which they received, depositing in these altered words and modes of speech the spirit, the ideas, the thought of their lifetime. These words and modes of speech they handed to us in our infancy, as the mould wherein to shape our minds, as the shell wherein to envelop our slowly growing thoughts, as the instrument with which to convey our ideas. In their language, in the phrases and catchwords peculiar to them, we learnt to distinguish what was important and interesting from what was trivial or indifferent, the subjects which

18 Changes which Language undergoes from parent to child, a proof of the changing life of Thought.

should occupy our thoughts, the aims we should follow, the principles and methods which we should make use of. The bulk and substance of this they indeed inherited themselves; but the finer distinctions of their reasoning, the delicate shading of their feelings and aspirations, they added and modified for themselves, modelling for their own special use the pliable and elastic medium of the mother tongue. With this finer moulding we have inherited the spirit of the former generation: predisposing us to certain phases of thought and placing in our path a difficulty in acquiring otherwise than by gradual and almost imperceptible degrees the faculty of assimilating new and unexpected opinions, tastes, and feelings. Many of us adhere to the special character and phase of thought acquired in our youth. Some by learning foreign languages, and living in other countries, gain a facility for understanding quite different phases of thought: very few among us develop so much original thought that they burst the shell of conventional speech, coining new words and expressions for themselves, embodying in them the fleeting ideas of their time, the indefinable spirit of their age. Once expressed, these new terms are rapidly circulated, and if we look back on the period of a generation, we note easily the progress and development of opinion and tastes in the altered terms and style of our language.

19. Inadequacy of conventional speech for original thought. Coining of new words.

Thus it is that the writer, and those of his readers whose memory carries them back to the middle of the century, and whose schooling and education embodied the ideas of a generation before that time, can claim to have some personal knowledge of the greater portion of the nineteenth century, of the interests which it created and

the thoughts which stirred it.[1] It is the object of these volumes to fix, if possible, this possession, to rescue from oblivion that which appears to me to be our secret property; in the last and dying hour of a remarkable age to throw the light upon the fading outlines of its mental life, to try to trace them, and with the aid of all possible information, gained from the written testimonies or the records of others, to work them into a coherent picture, which may give those who follow some idea of the peculiar manner in which our age looked upon the world and life, how it intellectualised and spiritualised them. This attempt is therefore not a history of outward political changes or of industrial achievements: the former will probably be better known to our children than they have been to us, the latter will soon be forgotten as such, or incorporated in the still greater results of the future, for which they will be the preparation. Nor is it a history of Knowledge and Science, of Literature and Art, which I purpose to write; though as these are the outcome of the inner life, and contain it, so to say, in a crystallised form, they will always have to be appealed to for the purpose of verifying the conclusions which we may arrive

20. Object of this work to retrace the life of Thought through the dying century.

21. Not a political history, nor a history of Science, Literature, and Art

[1] On the division of History into centuries see what Du Bois-Reymond says ('Reden,' Leipzig, 1886, vol. i p. 519), and the fuller discussion of the subject by Prof. O. Lorenz, 'Die Geschichts-wissenschaft' (Berlin, 1886, p. 279 *sqq.*) The latter refers to what the first historian says (Herodotus, ii. 142: *Καίτοι τριηκόσιαι μὲν ἀνδρῶν γενεαὶ δυνέαται μύρια ἔτεα γενεαὶ γὰρ τρεῖς ἀνδρῶν ἑκατὸν ἔτεά ἐστι*). A person born in 1840 can claim to have a personal knowledge of the last half, and through his parents and teachers a knowledge of the first half, of the century. In this way it may be said that his personal—direct or indirect—knowledge extends over nearly a century. Lorenz says correctly. "Fur jeden einzelnen bildet der Vater und der Sohn eine greifbare Kette von Lebensereignissen und Erfahrungen" And that this applies even more to ideas and opinions, to Thought, than to events and facts, is evident.

22. Where the interest of the book will lie. In all the influences which have a result on our inner life

at. What will interest us most will be the conscious aims and ends, if such existed, of any political or social movement, and, where they did not exist, at least the results to our inner life which have necessarily followed, the methods by which knowledge was extended or science applied, the principles which underlay literary composition and criticism, and the hidden spiritual treasure which poetry, art, and religious movements aimed at revealing or communicating, in fact the question: What part has the inner world of Thought played in the history of our century,—what development, what progress, what gain has been the result of the external events and changes?

23. The personal knowledge and experience necessary for a true portrayal forms a limitation of the extent of ground to be traversed

But if personal knowledge and experience are—as it seems to me—of the greatest importance in an attempt like this; if, without having lived the inner life, a record of it would be either a mere string of names or a criticism of opinions, not a living picture,—so it is also the factor which necessarily limits the extent of the ground which I propose to traverse. Thus I feel obliged in the first place to limit myself to European Thought. Such a limitation would hardly have been called for a century ago, because it would have been a matter of course: but the steady growth and peculiar civilisation of a new and vigorous people on the other side of the Atlantic force

24. American influence only touched upon.

from me the twofold confession, that there is a large world of growing importance of which I have no personal knowledge, and to estimate which I therefore feel unqualified and unprepared; and further, that I am equally unable to picture to myself the aspect which the whole of our European culture in its present state may assume to an outside and far-removed observer who is placed in the

New World. As this New World grows not only in numbers and national wealth, but also in mental depth, as it becomes more and more intellectualised and spiritualised, so it will no doubt experience the desire of recording its own inner life and culture, emphasising the peculiarities which distinguish it as a whole from our civilisation. But the tendencies of this new culture are to me vague and enigmatical, and I frankly admit that I am unable to say anything definite on this subject. Convinced as I am that in human affairs all outer life is the vessel which contains an inner substance, the shell which envelops a growing kernel, I am, nevertheless, unable in this case to penetrate to either, and must therefore content myself with taking notice of this vast new element of nineteenth-century culture only where it comes into immediate contact with European thought, which has indeed been powerfully influenced by it. And of European thought itself I am forced to select likewise only the central portion, the thought embodied in French, German, and English Literature. I have to admit that Italian, Scandinavian, and Russian influences are all around this centre, sometimes penetrating far into it, but here again languages unknown and interests foreign to me have made it impossible to identify myself ever so superficially with the new life that is contained in them. I must therefore here also confine myself to very imperfect and casual notices, which make no attempt to do justice to the subject.

25. Only French, German, and English thought the subject of the present work.

The subject before us, then, is European Thought—*i.e.*, the thought of France, Germany, and England—during the greater part of the nineteenth century. Circumscribed as

this subject is by the limits of time and space which I have mentioned, it is, nevertheless, still vast, intricate, and bewildering. And yet it is my intention, throughout the inquiries which I have to institute and in the various outlines and sketches which I have to draw, never to lose sight of the unity of the whole. This unity, I maintain, the progress of our age has more and more forced upon us. It is itself a result of the work of the century. A hundred years—even fifty years—ago, it would have been impossible to speak of European Thought in the manner in which I do now. For the seventeenth and eighteenth centuries mark the period in which, owing to the use of the several vernacular languages of Europe in the place of the mediæval Latin, thought became nationalised, in which there grew up first the separate literature and then the separate thought of the different civilised countries of Western Europe. Thus it was that in the last century, and at the beginning of this, people could make journeys of exploration in the region of thought from one country to another, bringing home with them new and fresh ideas. Such journeys of discovery, followed by importation of new ideas, were those of Voltaire[1] to England in 1726, where he found the philosophy of Newton and Locke, at that time not known and therefore not popularly appreciated in France; the journey of Adam Smith in 1765 to France, where he became acquainted with the economic system of Quesnay and the opinions of the so-called "physiocrats," which formed the starting-point of his own great work,

26. Unity of Thought a product of this century.

27. Voltaire

28. Adam Smith.

[1] For a most complete collection of data referring to this subject see Du Bois-Reymond's address in the Berlin Academy, 30th January 1868, reprinted in the collection of his 'Reden,' Leipzig, 1886, vol. i.

'The Wealth of Nations.' During the last quarter of the eighteenth century A. G. Werner raised the Mining Academy at Freiberg, which had been founded in 1766, from a mere provincial institution to be one of the great centres of scientific light in Europe, to which students from all parts of the world flocked to listen to his eloquent teaching. Towards the end of the century Wordsworth and Coleridge went on a trip to Germany, whence the latter brought to England the new philosophy of Kant and Schelling. Madame de Stael, in an age when tidings of a new literary life in Germany had reached French Society through some of the emigrants of the Revolution, set herself reluctantly to learn German,[1] convinced that a new phase of thought had appeared there, and then with Benjamin Constant visited the country itself at the end of 1803, and again in 1807. The result of these journeys of exploration was her work 'De L'Allemagne.' Whilst Coleridge and Madame de Stael drew inspiration from the new life which centred in the Weimar of Goethe and Schiller, the scientific students of the whole Continent directed their gaze to Paris, where alone for many decades the modern methods could be learnt, where the new scientific ideas were, so to speak, collected in a focus. For more than half a century Paris remained the centre of scientific thought,[2] and even English philosophers, who

29. German thought brought to England by Coleridge and Wordsworth

30. German thought imported into France by Madame de Stael.

31 Paris the focus of scientific ideas.

[1] See Lady Blennerhasset's interesting work on Madame de Stael, German ed., vol. ii. p. 461 *sqq.*, especially the remarkable passage quoted there, p. 465, in her letter to the Baron de Gérando, October 1802: "Ich glaube wie Sie, dass der menschliche Geist, der zu wandern scheint, jetzt bei Deutschland angelangt ist."

[2] See Bruhns, 'Life of A. v. Humboldt,' translated by Lassell, vol. i. p. 232: "Notwithstanding the sardonic expression of the frantic judge, 'Nous n'avons pas besoin de savans,' Paris was yet at the close

since Bacon and Newton had followed their own independent line of research, had to discover in the second decade of the century that Newton's great name was not a guarantee for the efficiency of his methods, which had been greatly developed and improved in the hands of Continental mathematicians. These improved methods were imported into England by three Cambridge graduates, Herschel, Babbage, and Peacock, who translated Lacroix's Treatise, and by doing so gave a great impetus to mathematical research in this country. Fifteen years later, students from all parts of the world flocked to the small University town of Giessen in Germany, thence to take home with them a knowledge of the new science and methods of Chemistry, taught in the laboratory of Liebig—methods previously used only in the private and inaccessible laboratories of learned investigators.[1] It will be in the memory of many how the philosophy of Auguste Comte, published between the years 1830 and 1840, remained without much influence in his own country, whereas, mainly through the writings of J. S. Mill and

32. Continental mathematical methods introduced into England by Babbage, Herschel, and Peacock.

33. Liebig's Laboratory.

34 Comte's philosophy shown to his own country by an Englishman.

of the eighteenth century the metropolis of the exact sciences. Lalande, in writing to von Zach on January 26, 1798, remarks: 'The love of mathematics is daily on the increase, not only with us but in the army. The result of this was unmistakably apparent in our last campaigns. Bonaparte himself has a mathematical head, and though all who study this science may not become geometricians like Laplace and Lagrange, or heroes like Bonaparte, there is yet left an influence upon the mind which enables them to accomplish more than they could possibly have achieved without this training. Our mathematical schools are good, and successfully accomplish their main object in the diffusion of mathematical knowledge.'" Compare also vol. i. p. 342, referring to 1804. Also vol. ii. p. 92, referring to the period 1820 to 1830. "Humboldt continued to regard Paris as the true metropolis of Science" (p. 70), and many other passages. See also Steffens, "Was ich erlebte," vol. x. p. 233, and what Goethe said to Eckermann on the contrast of Germany and Paris in the year 1827.

[1] See A. W. Hoffmann, 'The Life-Work of Liebig,' Faraday Lecture for 1875, p. 8.

his school, it became, as it were, a centre of thought, an embodiment of a circle of modern ideas in this country, whence it was reimported into France nearly a generation after its first appearance. Something similar happened to a once neglected but now renowned English landscape-painter, Constable, whose pictures when exhibited in France in 1824 created a profound sensation, and had such an influence on the artists of that country that they are said to mark an era in landscape-painting there.[1]

35. Constable's influence in France.

Such journeys of discovery in the realm of thought and ideas have now become almost impossible. In the course of our century Science at least has become international: isolated and secluded centres of thought have become more and more rare. Intercourse, periodicals, and learned societies with their meetings and reports, proclaim to the whole world the minutest discoveries and the most recent developments. National peculiarities still exist, but are mainly to be sought in those remoter and more hidden recesses of thought, where the finer shades, the untranslatable idioms, of language suggest, rather than clearly express, a struggling but undefined idea. Thought has its dawn and twilight, its chiaroscuro as well as its open day; but the daylight has grown wider and clearer and more dif-

36. Science become international

[1] See Walter Armstrong in the 'Nineteenth Century' for April 1887, Julius Meyer, 'Geschichte der modernen franzosischen Malerei,' Leipzig, 1867, Book 7, chap. 2; A. Rosenberg, 'Geschichte der modernen Kunst,' vol. i. p 63. Rosenberg thinks the influence of Constable on French Art is exaggerated, and mentions Paul Huet, whose early pictures date from 1822. But an Englishman, Bonington, who, however, is claimed as of the French School, was even before Huet and Constable. See also what Delacroix wrote to Th. Sylvestre in 1858: "Constable est une des gloires anglaises. C'est un véritable réformateur, sorti de l'ornière des paysagistes anciens Notre école a grandement profité de ses examples et Géricault était revenu tout étourdi de l'un des grands paysages qu'il nous avait envoyés" (quoted by Emile Michel in 'Grande Encyclopédie,' art. "Constable").

fused in the course of our century, and so far as the greater volume of ideas is concerned, we can speak now of European thought, when at one time we should have had to distinguish between French, German, and English thought. Reserving, therefore, in the meantime the task of investigating what still, within the bounds of this larger international life, remains peculiar to the thought of each nation, it is the great body of common European thought with which I propose at first to deal. How has it grown to be what it is now, what special contributions have the several nations made to the general stock, what is at present our inventory of it, how has it been changed in course of the century? But how, it may be asked, are we to take stock? how is this inventory to be drawn up? There is indeed one very obvious method which presents itself, though it is not the one which I propose to use exclusively, or even largely. And yet it seems to me well worthy of special attention.

37. The light which Etymology throws on history of Thought,

Already I have remarked how the changes of thought are deposited in the altered language and style of the age. A closer study of the changes which, in the course of this century, have taken place in the vocabularies as well as in the styles of the three principal European languages would no doubt reveal to a great extent when and how new ideas have presented themselves, how they have become fixed and defined in special words or terms. It would allow us to trace to a very large extent not only the growth of the general stock of European thought, but also the migration of single ideas from one nation to another. And, lastly, it would exhibit to a great extent in what peculiar phrases, in what secluded corners, the

38 and on the migration of ideas.

individual thought of each of the three nations has found refuge.[1] Any one who has attempted to translate from one of these languages into another, be it prose or be it lyrical, philosophical, or descriptive poetry, will have experienced the necessity of studying minutely the meaning or hidden thought which a word or a phrase may signify: he will have been led to notice what is common and what is peculiar to different languages,

[1] The only books which treat of words in the sense mentioned above, and which have come under my notice, are Horne Tooke's 'Diversions of Purley' and Archbishop Trench's little volumes on 'The Study of Words' and 'English Past and Present' So far as the use of merely philosophical terms is concerned, I may refer to R. Eucken, 'Geschichte der philosophischen Terminologie,' Leipzig, 1879. A great deal of material for a research of this kind may be found in the large Dictionaries of Grimm, Littré, and Murray, though I do not feel sure that the great change which has come over language, through the expansion, deepening, and differentiation of ideas and of thought in our age, has been specially taken note of. The plan of Grimm's Dictionary, which aims at embracing the German language in its development during three centuries, beginning with Luther and ending with Goethe (see Wilh Grimm's 'Kleinere Schriften,' vol. i. p 508), almost excludes the period which I am reviewing

It is interesting to remember that Diderot, the first writer who attempted to collect the great body of modern Thought and Learning into an encyclopædic whole, referred to Language very much in the same manner as we do now, a hundred and fifty years later. See the article "Encyclopédie," where Diderot says that a Dictionary is only an exact collection of titles, to be filled in by the Encyclopædia, and further on, p 639: "Si l'on compte les hommes de génie, et qu'on les répande sur toute la durée des siècles écoulés, il est évident qu'ils seront en petit nombre dans chaque nation et pour chaque siècle, et qu'on n'en trouvera presqu'aucun qui n'ait perfectionné la langue. Les hommes créateurs portent ce caractère particulier. Comme ce n'est pas seulement en feuilletant les productions de leur contemporains qu'ils rencontrent les idées qu'ils ont à employer dans leurs écrits, mais que c'est tantôt en descendant profondément en eux-mêmes, tantôt en s'élançant au dehors, et portant des regards plus attentifs et plus pénétrans sur les natures qu'ils environnent, ils sont obligés, surtout à l'origine des langues, d'inventer des signes pour rendre avec exactitude et avec force ce qu'ils y decouvrent les premiers. C'est la chaleur de l'imagination et la méditation profonde qui enrichissent une langue d'expressions nouvelles: c'est la justesse de l'esprit et la sévérité de la dialectique qui en perfectionnent la syntaxe, c'est la commodité des organes de la parole qui l'adoucit; c'est la sensibilité de l'oreille qui la rend harmonieuse."

39. Goethe.

and the thought which they express. Of Goethe it may be said that he created to a large extent the language and style of that which is best in the modern literature of his country. No such supreme influence belonging to a single individual can probably be found in any other German, French, or English writer in our century, for reasons which are obvious: but the great French novelists, the German metaphysicians, and the original poetical minds of modern England have enlarged and enriched the vocabulary of their respective languages, and have added a number of useful and novel modes of expression (*tournures, Wendungen*). Carlyle's influence has been great in introducing novel epithets, borrowed or imported frequently from the German. Matthew Arnold has laboured in a similar direction, his models being, besides Goethe and Heine, mostly French authors, such as Sainte-Beuve and the introspective school.

40. Peculiarity of the German Language.

Germany has been less fortunate in extending her vernacular vocabulary: the facility which her language possesses of assimilating foreign words and using them almost without any alteration has done much to complicate German style, destroying its simplicity, its graces, the poetical element. It will, however, probably be found that by far the greatest accession to the vocabularies—though not to the finer modelling—of the modern languages has come from the influence of the sciences on general culture and literature.

41. Growth in the meanings of words.

Well-known words, long in use, have at the same time through this influence acquired altered or more specific meanings.

The vaguer word "development" has been supplanted by "evolution." "Differentiation" has a definite philo-

sophic—not only a mathematical—meaning. The word "positive" has, besides the logical signification, acquired at least two meanings which are very specific, and which it did not possess formerly. "Energy" has, besides the general meaning, and the philosophical one which Aristotle assigned to it, acquired a special meaning, having first in England and then abroad taken the place of "force" as a more correct and definable term. In connection with it, "correlation" and "conservation" are terms of very specific value. The word "fittest" and the phrase "struggle for existence" mean something different from what they meant fifty years ago. Then there are the terms "exact" and "science" themselves, which mean something different now from what they meant formerly. And coming out of the more recent doctrines of the limits of human and conscious individual knowledge, there are the words "unconscious," "unknowable," and "agnostic," which indicate whole trains of novel thought. It would indeed be an interesting and useful investigation to follow up to their origin the many new words and phrases, or the altered meanings of well-known and familiar words, in which the three principal European languages abound. It would be a methodical study of the changes which thought has undergone.

42. New thought has found new words.

Nor need such an undertaking be based upon any particular or one-sided theory as to the connection of Civilisation, Thought, and Language. This century has not been wanting in such, from the extreme theory of De Bonald,[1] who saw in Language an immediate Divine revelation, to the most recent and more scientific view

43 De Bonald's theory of revealed Language and Max Müller's Science of Language.

[1] De Bonald (1754-1840), 'Législation primitive,' Paris, 1802.

of Max Müller, who would absorb philosophy in the science of Language[1] in the same way as Astronomy has to many become merely "une question d'analyse." In a certain sense we can agree with both of these thinkers. Without discussing the vexed question of the origin of Language and Thought, to us as individuals, born in a civilised and intellectual age, words certainly came earlier than clear and conscious thought. The easy manner also in which, through the use of our parents' tongue, we became introduced into a complex and bewildering labyrinth of highly abstract reasoning is little short of a miraculous revelation. But, as I mentioned above, it is not my intention to study the development of European thought during this century by means of a close analysis of the changes and growth of the three principal languages. Such an enterprise would demand an amount of lexicographical knowledge possessed only by the authors of dictionaries like those of Grimm, Littré, and Murray. But though I am not qualified for such a task, there is one special point on which I cannot avoid being drawn into a grammatical discussion. It refers to the word Thought itself. How is the meaning which I and my readers connect with this word to be expressed in French and German? How are we to translate the word? The subject we deal with does not belong to England alone, but as much to France and to Germany: it must thus have a name in each of their languages. Now I believe that the word *pensée* expresses in French very nearly the same thing which we mean in English by thought. It is some-

44. Thought, how expressed in French and German.

[1] See his 'Science of Thought,' London, 1887, especially pp. 292 and 550.

what more difficult to find a corresponding word in German. I have for some time hesitated whether to use the word *Geist* or *Weltanschauung*, two terms frequently used to express the aggregate of the inner life of an age: but have finally resolved to use the word *Denken*, as this word lends itself to the same contrasts of Life and Action (*Leben und Handeln*), denoting the inner world, whereas the opposite of *Geist* is *Stoff* (matter), and *Weltanschauung*, though an expressive and untranslatable word, denotes rather the outcome, the result, of thought than thought itself Passing from the word to the subject itself, I find that the greater definiteness of the term in the English language is accompanied also by a more abundant literature of the subject. The larger idea of a Philosophy of History is indeed due mainly to Continental thinkers, especially to Herder, Hegel, Comte, and Guizot, and Voltaire's 'Siècle de Louis XIV.' will always be the model of the historical picture of a period. Still it is—in my opinion—mainly the writings of Carlyle, Buckle, Draper, Lecky, Leslie Stephen, and, considering its size, perhaps more than all, Mark Pattison's 'Essay,'[1] which have fixed in our minds the meaning of the word Thought as the most suitable and comprehensive term to denote the whole of the inner or hidden Life and Activity of a period or a nation. I therefore put in a claim to start with the use of the English word, as sufficiently familiar to most of my readers, and request those who may object to the vagueness of the French

45 Philosophy of History due to Continental thinkers.

[1] See 'Essays and Reviews,' 'Tendencies of Religious Thought in England, 1688-1750,' by Mark Pattison, also Leslie Stephen's remarks on it in the Preface to his 'History of English Thought in the Eighteenth Century.'

and German equivalents to look for a definition of my intention in the English word "Thought." I am not aware that French literature possesses any "histoire de la pensée," either of a longer or shorter period; I know of innumerable works in German which cover a similar field, but they have mostly used the word *Weltanschauung*, or expanded the meaning of Thought into the wider sense of a history of Civilisation (*Kulturgeschichte*) or narrowed it to that of Literature, proving—as it seems to me—the real want of a concise term such as the English language now supplies. And yet, I think I am right in saying that the conception of Thought, in the sense in which I am using it, is truly an outcome of international, not of specifically English progress, and belongs mainly to the period of which I am treating,—a period characterised, as I have already remarked, by the great interchange of ideas, by the breaking down of intellectual barriers, between the principal European nationalities. It was above all in the mind of Thomas Carlyle, who first among Englishmen made a profound study of the intellectual agencies which brought about the great change in modern Europe, that the conception formed itself of an intellectual and spiritual organism, underlying and moving external events. He first gave the peculiar sense to the word Thought, in which we here employ it, and made it an object of special study for those who came after him; an object, indeed, definable in various ways and to be contemplated from differing points of view, but yet a something, a power recognised by every one, and for which no better word could be invented. No other language has a word so comprehensive, denoting at once the process and

46. Want of precise term in German and French.

47. Conception of Thought nevertheless not specifically English.

48. Carlyle the first to give a special meaning to the word Thought.

the result, the parts and the ideal whole, of what is felt and meant: it commits us to no preconceived theory, can be used equally by thinkers of the most opposite views, and lends itself to any specialisation which may become necessary.

II.

1 The two factors of intellectual progress.

Two processes have helped to determine the intellectual progress of mankind. These two processes have often been apparently opposed to each other in their operations; but in reality neither of them can proceed very far without calling the other into existence. They are the extension and the condensation of knowledge. Curiosity, the demands of practical life, the experiences of every day, all tend to an enlargement, to an accumulation of knowledge. Such growing knowledge is, however, of little avail if it be not readily grasped: the command of knowledge is as important as its accumulation. The more extensive the country which we wish to explore, the more we look out for elevated and commanding points of view, which permit us at a glance to overlook a wide landscape measuring the distance behind or the prospect before us. But, however enticing, these elevated views are frequently seductive and misleading. They permit us not only to look backward on the land which we have explored, giving us a clearer picture of its many features, of its winding paths, of the position of its separate objects —these elevated views present to us likewise the regions which we have not yet explored, and suggest the attempt to supersede the laborious process of further exploration

by the more delightful venture of filling up the dim outlines which we see before us, with analogies of past experience or creations of our imagination. And even if we do descend into the plains and continue the minuter and more laborious search, we cannot rid ourselves of certain preconceived but frequently misleading ideas which the superficial glance has impressed on our minds.

The condensation may become an idealisation of knowledge. History affords numerous examples of these different stages of progress, centuries of dull accumulation, of unmethodical and ill-arranged learning, have been followed by short periods of enlightenment, by the triumphant shout of sudden discovery or the confident hope of invention. Patient work and real progress have for a long time been repressed by the allurements of seductive phantoms, which have had to be abandoned after an immense waste of labour. New prospects have suddenly opened the view into vast unexplored regions, heights have been gained from which the whole of human knowledge appeared for the moment condensed into a single truth or idealised into a vision, and again these delightful achievements have for a time appeared lost in an all-pervading discouragement and dismay.

2. Object of the book.

Whether our century has been characterised by any one or by a succession of several of these varying moods, is a question which I hope to answer in the sequel. For the present it is sufficient to note that in both directions—in that of accumulating and in that of condensing and idealising knowledge—the efforts of the nineteenth century have been many and conspicuous. In the former it is altogether unparalleled, whereas in the latter it has

3 Nineteenth century unequalled in accumulation of knowledge.

probably not equalled the ideal greatness of Greece in the Periclean age, the brilliancy of the Renaissance in Italy, or the great discoveries of the sixteenth and seventeenth centuries in France and England. But what our century has done is this: it has worked out and deposited in special terms of language a clearer view of the correct methods for extending knowledge, and a peculiar conception of its possible unity. At one time—and that not very long ago—the word truth seemed to indicate to the seeker not only the right method and road for attaining knowledge, but also the end, the crown of knowledge. "Truth, and nothing but truth," seems still to the popular mind the right maxim for seeking knowledge—the whole truth stands before it as the unity of all knowledge, were it found. I think it is now sufficiently clear to the scientific inquirer, as well as to the philosopher, that love of truth, while it does indeed denote the moral attitude of the inquiring mind, is insufficient to define either the path or the end of knowledge. "What is truth?" is still the unsolved question. The criteria of truth are still unsettled. It would, indeed, be a sorrowful experience, a calamity of unparalleled magnitude, if ever the moral ideas of truth and faith should disappear out of the soul of either the active worker or the inquiring thinker; but it is with these as with other treasures of our moral nature, such as goodness and holiness, beauty and poetry—our knowledge of them does not begin, nor does it increase, by definition, and though in the unthinking years of our childhood we acquire and appropriate these moral possessions through the words of our mother-tongue, they rarely gain in depth or meaning by logical distinctions which we may learn,

4. Nineteenth century, what it has achieved. *a.* Method of knowledge; *b.* unity of knowledge.

5. Search after truth not the end of knowledge, only the attitude of the inquiring mind.

or to which we have to submit, in later life. These do not touch the essence, though very frequently they may succeed in destroying the depth, of our convictions.

6. Method of scientific inquiry Practised first by Galileo, Newton, &c., defined by Bacon, Comte, Mill, &c.

In the place, then, of the high-sounding but indefinable search after truth, modern science has put an elaborate method of inquiry: this method has to be learnt by patient practice, and not by listening to a description of it. It is laid down in the works of those modern heroes of science, from Galileo and Newton onward, who have practised it successfully, and from whose writings philosophers from Bacon to Comte and Mill have—not without misunderstanding and error—tried to extract the *rationale*. These methods will take up a large portion of our attention. For the moment it is important to note that the result or aim of scientific inquiry does not dictate the methods,—the purely scientific inquirer does not know where the path will lead him: it is sufficient that it be clearly marked. Modern science defines the method, not the aim, of its work. It is based upon numbering and calculating - in short, upon mathematical processes; and the progress of science depends as much upon introducing mathematical notions into subjects which are apparently not mathematical, as upon the extension of mathematical methods and conceptions themselves. The terms "exact" and "positive" are current in the Continental and English languages to denote these methods and their application. Now to any one who does not stand in the midst of the scientific work of the age, it might appear as if by merely following a defined method which is capable of numerous modifications,—by treading a clear path which in its course leads us to endless equally defined ramifications,—the scientific

7. Disintegration of learning only apparent.

inquirer is losing daily more and more those elevated views, those points of condensation, those unifying and idealising aspects on which, as it seems to us, the command and grasp of knowledge depends. This is indeed almost inevitable so far as the older ideas are concerned. Unity of knowledge, order and harmony, even completeness and symmetry, truth and beauty, are indeed no longer of direct use as canons for the scientific inquirer, any more than the mysteries once supposed to be inherent in certain numbers. Though we still live under the charm of such entities, however much we may try to get rid of them, it must nevertheless be admitted that the poetical, philosophical, and religious aspects of things seem to recede into an increasing distance from the scientific; they do not guide scientific search; it does not receive from them much support. Have both sides been losers by this change? So far as science is concerned, it can claim to have attained by it not only a greater formal completeness and certainty of progress, but also another very important advantage which was unknown to ancient and mediæval research.

8. Apparent distance between science and poetry.

This advantage consists in the closer connection between science and practical life. The same mathematical spirit which governs scientific methods rules also in trade, commerce, and industry, and is gradually penetrating into the professions, such as medicine, law, and administration. For all these pursuits have either directly to do with numbers, measures, and weights, with distances of space and time, or they have found it necessary to introduce an elaborate system of statistics and averages through which the irregularity and captiousness of subjective and individual influences are practically eliminated. The

9. Closer connection between science and life.

problems of scientific research have thus enormously increased; each advance in science increases our command of certain measurable phenomena in practical life; each new development in the latter prepares a new field for scientific inquiry. The contact between science and life has become more intimate in the course of our century. This to a great extent has counterbalanced the tendency of modern scientific method, which, operating alone, would have led to endless specialisation; for it is the peculiarity of all practical problems that they cannot be isolated in the same way as scientific experiments—that they, in fact, force upon us the necessity of looking at a large number of surrounding and extraneous circumstances, at the totality of life and its interests.[1]

10 Solidarity of all practical problems.

If our century can claim to have firmly established exact or positive methods in science and life, and to have furthered in this way the interests of both, the question remains, Has nothing been done to uphold those older, those time-hallowed ideals of truth, beauty, and wisdom which to former ages seemed to denote the unifying and harmonising principles of science and life? What has become of philosophy, art, and religion, which were once intrusted with the special care of those ideals, charged with preventing the falling asunder of the many branches of knowledge and practice, and expected to save us from a loss of the belief in the integrity, interdependence, and co-operation of all human interests?

11. What has the nineteenth century done for the ideals of life?

[1] Science deals with things in the abstract, in their isolation, *in vacuo*. Practical life deals with the same things in their position in the real world, surrounded by other things. In this distinction lies the value of Lotze's definition of the reality of a thing as "a standing in relation," *viz.*, to other things, to all things. See 'Microcosmus,' book ix.

Unless I believed that our age was elaborating a deeper and more significant conception of this unity of all human interests, of the inner mental life of man and mankind, I do not think I should have deemed it worth while to write the following volumes: for it is really their main end and principal object to trace the co-operation of many agencies in the higher work of our century; the growing conviction that all mental efforts combine together to produce and uphold the ideal possessions of our race, that it is not in one special direction nor under one specific term that this treasure can be cultivated, but that individuals and peoples in their combined international life exhibit and perpetuate it.

12 Deeper conception of the unity of human interests.

A number of words have during this century been introduced by various systems of philosophy to denote this unity of the inner life of mankind Hegel's *Geist*, Comte's Humanity, Lotze's Microcosm, Spencer's Social Organism, all refer to special sides and aspects of the same subject. And it is interesting to note how the great schools of Idealism in Germany, of Positivism in France, of Evolution—physical and mental—in England, and—in spite of their apparently disintegrating tendencies—how the social changes of the Revolution and the specialisations of science have all combined to emphasise this unity of human life and interests. To show this in detail is the object I have in view. So far we have not committed ourselves to any of the many existing theories: the word Thought seems to me to be capable of the widest application, and to denote in the most catholic spirit whatever of truth and value may be contained in the combined aim and endeavour of

13. Different terms for expressing this unity

14. Definition of Thought.

all these modern aspirations. A history of this thought will be a definition of Thought itself.

Much has been done in the course of this century to prepare for an undertaking such as the one before me. It will be well to review shortly this special side of modern literature. We have indeed passed out of what may be called the age of encyclopædic treatment of learning—the hundred years from the middle of the last to the middle of the present century.[1] The plan of such an arrangement of knowledge belongs to an earlier period, the period immediately succeeding the birth of modern science. Lord Bacon was the father of it, but neither he nor the most encyclopædic intellect of modern times, Leibniz, did much to realise the idea, and it was reserved for the genius and the labours of Diderot and d'Alembert[2] in France, in the

15. 1750 to 1850. The age of encyclopædic treatment of learning.

[1] "Encyclopædia nomen hodie frequentius auditur quam alias."—Gessner in Gottinger Lections-Katalog for 1756.

[2] Diderot's "Prospectus" to the 'Encyclopédie' appeared 1750; the first volume appeared 1751 with the celebrated "Discours préliminaire" of d'Alembert and a reprint of the "Prospectus." The complete title was 'Encyclopédie ou dictionnaire raisonné des sciences, des arts et métiers, par une société de gens de lettres, mis en ordre et publié par Diderot et d'Alembert.' The principles which guided the editors, and the object of the work, are explained, with repeated references to Lord Bacon, in this introduction, as well as in the article "Encyclopédie," in the fifth volume (1755), which was written by Diderot, and occupied 28 pages. See also Diderot's 'Pensées sur l'interprétation de la Nature,' published anonymously in 1754.

Copious details about the history, the reception, and the influence of the 'Encyclopédie' are to be found in the correspondence and memoirs of Grimm, d'Alembert, and Voltaire, Madame d'Épinay, the Abbé Morellet, and many others. They are combined into a concise narrative, giving all the important facts, in Rosenkranz's 'Leben und Werke Diderots,' 2 vols., Leipzig, 1866, and in John Morley's 'Diderot.'

It is interesting to note how the idea of the unifying and life-giving influence of thought was as familiar to Diderot as it is to us: "Si l'on bannit l'homme ou l'être pensant et contemplateur de dessus la surface de la terre; ce spectacle pathétique et sublime de la nature n'est plus qu'une scène triste et muette. L'univers se tait; le silence et la nuit s'en emparent. Tout se change en une vaste solitude, où les phénomènes inobservés se passent d'une manière obscure et sourde. . . .

middle of the eighteenth century, to carry out the plan, foreshadowed in the 'Novum Organum,' of collecting all knowledge, which had been accumulated ever since science had been liberated from the fetters of theology, into one comprehensive whole. It must, however, be admitted that whilst the practical end of these laborious undertakings, the diffusion of knowledge, has certainly been greatly furthered, the original idea, that the sum of human knowledge is an organic whole, has in the execution been by degrees entirely lost sight of. The unity of thought and knowledge was indeed referred to in Diderot's "Prospectus" and d'Alembert's "Discours préliminaire," and in the introduction to Ersch and Gruber's great Encyclopædia,[1] as also in Coleridge's celebrated essay

16. Unity of knowledge gradually lost sight of in encyclopædic works.

Voilà ce qui nous a déterminé à chercher dans les facultés principales de l'homme la division générale à laquelle nous avons subordonné notre travail"—Article "Encyclopédie,' p. 641.

[1] Ersch und Gruber's 'Allgemeine Encyclopadie der Wissenschaften und Kunste,' Leipzig, 1818 to 1875, unfinished, 151 vols. It was founded by Professor Johann Samuel Ersch, librarian at Halle in 1813, assisted by Hufeland, Gruber, Meier, and Brockhaus, and contained contributions by the most learned and eminent Germans of the century. It is interesting to compare the plan and principles which guided the editors, as expounded in the introductions to the first and second volumes, with the corresponding dissertations prefixed to the 'Encyclopédie' in France and the 'Encyclopædia Metropolitana' in England. The unity aimed at by Bacon was either purely formal, securing only uniformity and completeness of treatment, or it was that of practical usefulness—the philosophy of fruit and progress. The plan adopted by Diderot and d'Alembert could hardly attain anything more than this Coleridge, nursed in German philosophy, and deeply impressed with the fact that there is a higher view than that of Lord Bacon, and that such is to be found rather in writers like Plato and Shakespeare, uses the word method in a much wider sense. He was deeply affected by the spirit of the idealistic philosophy, which was foreign to Bacon and unduly despised by him.

In the idealistic systems of the Continent, beginning with Kant, the opinion was current that the methods and treatment of science alone were insufficient to close the circle of knowledge The truly encyclopædic view was only possible in a scientific investigation specially carried on for that purpose, and this was considered to be one of the main objects of philosophy. Thus Kant in many passages of his works, notably vol. ii. pp. 377, 378,

on the science of method prefixed to the 'Encyclopædia Metropolitana'; but the result has shown, what was not evident to Lord Bacon, that neither a systematic division of learning according to some logical principle, nor the historical identity of the beginnings of all branches of knowledge, can in the end preserve the real unity and integrity of thought. The work of the advancement of learning, if it be once handed over to different sciences and intrusted to separate labourers, does not proceed in a cycle which runs back into itself, but rather in the rings of an ever-increasing spiral, receding more and more from the common origin. Such is the impression we get if we contemplate the unfinished[1] rows of Ersch and Gruber's

613; vol. iii. pp. 188, 212; vol. v. p 312 (Rosenkranz's edition), especially the two following: "Philosophy is the only science which can procure for us inner satisfaction, for she closes the scientific cycle, and through her only do the sciences receive order and connection." And: "Mere 'πολυιστορία' is a cyclopean learning which wants one eye—the eye of Philosophy—and a cyclops among mathematicians, historians, naturalists, philologists, and linguists, is a scholar who is great in all these lines, but having these considers all philosophy as superfluous." Still, with Kant Philosophy is not an "instrument for the extension," but merely a study of "the limits of knowledge"; she does not "discover truth," but only "prevents error." This modest definition was given up in the systems of Fichte, Schelling, and Hegel, who maintained that a certain kind of—and thus the highest—knowledge could be attained by starting from one highest principle deductively: the all-embracing, encyclopædic character of philosophical, speculative knowledge was increasingly emphasised, and this not only in special lectures on the subject, as in Fichte's lectures on "The Nature of the Scholar," in Schelling's on "The Method of Academic Study," in Hegel's 'Encyclopædia of Philosophy,' but also in the regeneration and reform of many older and in the foundation of new universities and academies throughout Germany. The great 'Encyclopædia' of Ersch and Gruber was planned in a similar spirit, as the reform of university teaching and of academic learning. This reform has been of the greatest importance to the German nation and to the interests of science and knowledge. The Encyclopædia, on the other hand, has remained incomplete, a huge but abortive attempt to combine not only the principles of knowledge, but also the colossal and growing volume of it, into a systematic whole.

[1] The promoters of it were evidently not sufficiently impressed with the two very essential conditions which make a work of this

volumes, or if we recognise the fact that the more useful and popular publications of our day have abandoned the philosophical introductions and preliminary discourses[1] by which the earlier works preserved a semblance of unity and method, and are contented to be merely useful dictionaries of reference. The encyclopædic treatment of knowledge, the execution of Lord Bacon's scheme, has shown that the extension and application of learning leads to the disintegration, not to the unification, of knowledge and thought. A conviction of this sort is no doubt the reason why in German universities lectures on "Encyclopadie" have been abandoned.[2] They were very general and popular in the earlier years of the century, when, under the influence of Kant, Fichte, and

17. Lectures on "Encyclopadie" abandoned in German universities.

kind useful—*viz*, that it must be finished, however imperfect it may be, and that it must be completed within a limited time, on account of the revolutions and smaller changes in thought and knowledge. These essential conditions were always before the mind of Diderot. See his article "Encyclopédie," pp. 636-644.

[1] The object of the philosophical introductions has in course of this century been much more completely attained by such works as Mill's 'Logic' and Jevons's 'Principles of Science', whilst the "preliminary dissertations," such as were contained in the older editions of the 'Encyclopædia Britannica,' have been partially superseded by works like Whewell's 'History' and his 'Philosophy of the Inductive Sciences,' in which the common origin, the genesis, the continuous development and interdependence of the different sciences, are traced The value in this respect of an undertaking like that of the Royal Bavarian Academy ('Geschichte der Wissenschaften in Deutschland,' vol. 1, 1864: it has now reached 22 vols., the science of War significantly filling three large volumes, that of Mathematics one small one) is much diminished by the title suggesting that science is a national, not a cosmopolitan or international concern. Fortunately many of the contributors to this important and highly useful publication have not limited their narratives to purely German science, but have largely taken notice of non-German research Special reports on the state of any science or branch of science in a nation have, of course, quite a different meaning and value.

[2] The term is still in use for courses of lectures giving a general and comprehensive view of special sciences: thus, "Encyclopadie des Rechts, der Medicin, der Philologie, der Philosophie, der Theologie."

Schleiermacher, university teaching and learning entered on a new era, in which the idea prevailed that completeness, universality, and unity of knowledge could be secured by one and the same arrangement of study.[1] It was the age when philosophy for the last time had got a firm hold of all departments of knowledge, and permeated all scientific pursuits;[2] when, favoured by political events,

[1] On this subject the literature connected with the foundation of the University of Berlin in the year 1809 is of special interest. It was essentially the creation of Wilhelm von Humboldt, though prepared by Wolf and Beyme in 1807. See Seeley, 'Life of Stein,' vol. ii. p. 430 *sqq.*; Haym, 'Leben W. v. Humboldts,' p. 270 *sqq.* The foundation of this university in the year of Prussia's greatest misery, when the first gleams of liberty in the rising of Spain and the success of Aspern had been extinguished by the defeat of Wagram, the voting of £22,500 per annum for the purposes of the new University and the Academy of Science and Arts, when a crushing war-tax hung over the country, when land was depreciated, the necessaries of life at famine prices, the currency of the country at a large discount, when every one, from the king to the lowest subject, was forced into sacrifices and economies of every kind, was an act as heroic as the great deeds on the battle-field, and as far-seeing as the measures of Stein and Scharnhorst. Interesting from our point of view are the ideas of Fichte on university teaching and academic learning, laid down in his 'Deducirter Plan einer zu Berlin zu errichtenden höheren Lehranstalt,' written at the request of the minister Beyme in 1807. In it a great deal is said about encyclopædic treatment. The question of the position of philosophy in the encyclopædic or academic treatment of knowledge was easily solved in the Kantian school, to which most of the above-mentioned writers belonged. Later on in the school of Schelling it became more difficult. It was frequently discussed by Schelling himself, who was one of those that initiated the new era in the Academy of Munich, which was remodelled in the year 1807. See, *inter alia*, Schelling's essay, "Suggestions concerning the Occupation of the Philologico-Philosophical Class" of the Academy, and especially the following remarkable passage ('Werke,' vol. viii. p. 464): "If, indeed, Philosophy were denied living contact with real things, if she were obliged to soar in transcendent regions without end and measure, and to rise a hungry guest from the well-appointed table of Nature and Art, of History and Life; then it would be incomprehensible how she could still find so much support as to be received in an academy, and it would be much better if we also followed the path of other nations, who have lately said good-bye to all philosophy, and have thrown themselves, with the most glowing ardour, upon the exploration of Nature and Reality in every direction."

[2] The principal representatives of the encyclopædic teaching at the German universities were Eschenburg, Krug, and Gruber. The latter, in his introduction to the

ideal aims, a generous spirit of self-sacrifice, and a feeling of one common duty pervaded the German nation, and foremost in it the teachers and students of the German universities.[1] This spirit, as it produced co-operation and unity of action, also favoured unity of thought, and contributed much to the popularity of several philosophical systems which promised more than they could give. Encyclopædic surveys were then supposed to be more than the empty shell, the mere skeleton of learning which they have since proved to be; they were looked upon as being able to grasp and convey the living spirit of knowledge. This phase of thought, which in the sequel will largely command our attention, has dis-

18. Encyclopædias did not fulfil what they appeared to promise.

second volume of Ersch and Gruber's 'Encyclopadie,' gives a definition and history of encyclopædic study, which, according to him, was introduced into the modern (German) universities together with the philosophical faculty In the beginning this was subservient to the three higher faculties (theology, law, and medicine), but gradually took the lead. He argues that only since university studies have become encyclopædic can they be considered as furthering true humanity. He refers to the great crisis through which in the beginning of the century literature, science, and arts were passing (p li), and mentions the conflicting principles in the treatment of mathematics, physics, history, philosophy, and philology. See also the 'Vorbericht,' vol. i. p. vii.

[1] Among the mass of literature dealing with this subject, the 'Memoirs of Frederick Perthes,' by his son (English translation, vol. i chap xi. *sqq.*), and Steffens's 'Autobiography' ('Was ich erlebte,' Breslau, 1840-44, 10 vols.), give the most vivid and exhaustive accounts. Neither Stein, the great statesman, nor Goethe, the great poet and thinker of the age, took part in this alliance of the patriotic and intellectual interests of the German nation. Stein's attitude to the idealism of the age is defined by Seeley, 'Life of Stein' (vol i p. 30, "It is desirable to mark that between him and the literature and philosophy of his time and country there was no connection at all"), and is expressed in a remarkable conversation which he had with Steffens, March 1813, at Breslau (quoted by Seeley, vol. iii. p. 119; Steffens, vol vii. p 120 *sqq*) Goethe's position is defined by his reply to the invitation to contribute to the 'Deutsches Museum,' a periodical planned by the bookseller Perthes. It was to be a scientific alliance of all the intellect of Germany, and was in time "to be transformed into a political one possessing the strength and union necessary for vigorous action" (Perthes' Memoirs, vol. i. p. 167).

appeared; the second half of our century does not expect to find the essence of knowledge condensed in any philosophical formula, any more than it expects to find the real unity and integrity of thought preserved in the fragmentary articles of an alphabetical dictionary. The purpose of the latter is purely practical; it is a popular and handy instrument for the diffusion of knowledge, whilst philosophical divisions are merely formal, and at best are applicable only to a narrow and limited sphere of research.[1]

The age of encyclopædic representation of learning and the short period of philosophical formalism seem both to belong to the past; but the desire of bringing together what is scattered, of focussing knowledge and learning, and of realising the organic continuity and unity of thought and progress, is as great as, perhaps greater than ever. Neither the shapelessness of a huge dictionary nor the barrenness of a concise formula will satisfy the

[1] It is interesting to observe the development and spread of encyclopædic learning in the three countries. Encyclopædias in the modern sense have their origin, like so many other modern institutions and ideas, in England. They were there compiled mainly for practical purposes. France took up the scheme in a philosophical spirit, and carried it as far as it is capable of being carried under this aspect. Attempts to improve and amplify the plan proved impracticable; and when subjected to the vast erudition of Germany, it became evident that unity, depth, and breadth of view could not be maintained. In course of this century the country which produced the classical era of encyclopedism has done least for encyclopædic learning. This has now its home in Germany, where encyclopædic labours have been specialised, and where every science is represented by some compilation or annual register aiming at collecting and systematically arranging the scattered contributions of the whole world. But it would be ungrateful not to mention the Royal Society's catalogue of scientific papers, and the services which America has rendered in summarising the literary productions of the English-speaking nations in such works as Poole's 'Index to Periodical Literature.' Without the aid of such laborious compilations the present work could not have been undertaken.

deeper conviction that all mental work is living, individual, and of endless variety. To stimulate individual thought, to bring about life and change, is nowadays felt to be quite as necessary as to insist on method, system, and order. Prompted by this conviction, the last fifty years have done much to facilitate intellectual interchange, and to record the historical development of all branches of science.

This object has been promoted in three different ways. The French, who in the beginning of the period were the masters in science, led the way by founding a series of periodicals devoted to the development of separate sciences. Germany followed, and still later England.[1] A living

19. French were the masters in science at the beginning of the century.

[1] The oldest scientific periodical is the 'Journal des Savants,' which was started in 1665 in Paris, next to it comes probably Rozier's 'Observations sur la Physique' (1771), continued under the title 'Journal de Physique' (1778, continued with interruptions from 1794-95 till 1823). In opposition to this journal, which defended the older phlogistic theories in chemistry, the 'Annales de Chimie' were started in 1789 by Berthollet, Guyton de Morveau, and Fourcroy, as an organ of Lavoisier's ideas. In 1788 the Société Philomatique started its 'Bulletin,' and in 1795 the 'Journal de l'Ecole Polytechnique' started its influential career. No such periodicals existed for special sciences at that time in any other country, if we perhaps except the 'Transactions of the Royal Linnæan Society,' which started in 1791. 'Nicholson's Journal' started in 1797; the 'London, Edinburgh, and Dublin Philosophical Magazine and Journal of Sciences' had its origin in Tilloch's 'Philosophical Magazine'; but the first journal devoted specially to mathematical sciences in England was probably the 'Cambridge Mathematical Journal,' started in 1839. In the meantime the number of scientific journals in France had grown enormously. In Germany we have Crell's 'Chemische Annalen' (1778), Gehlen's 'Allgemeines Journal fur Chemie' (1803), Gren's 'Journal der Physik' (1790), Gilbert's 'Annalen der Physik' (1799), Zach's 'Monatliche Correspondenz' (1800), Crelle's 'Journal fur die reine und angewandte Mathematik' (1826), and many others, all periodicals of the first importance. The 'Transactions of the Royal Society,' which of course contain many of the valuable scientific contributions of this country, can nevertheless hardly be looked upon as a repository of the work of English mathematicians and physicists of the period in question,—not even as much as the Memoirs of the Paris Academy in France. In Great Britain a new centre of scientific and literary work existed during the latter part of the last century

intercourse between men of science was greatly promoted by the British Association for the Advancement of Science, which held its first meeting at York in 1831. Associations and meetings of this kind had their origin ten years earlier in Germany through Oken;[1] but the line in which Germany has done most is the establishing of and continuing annual Reports[2] of the progress of the different

in Edinburgh ('Transactions of the Royal Society of Edinburgh,' started in 1788), and somewhat later likewise in Dublin ('Transactions of the Royal Society of Dublin,' started 1799), and Manchester ('Memoirs of the Manchester Philosophical Society,' started in 1789). Many of the first scientific writers of the age published in these provincial papers or in separate pamphlets—the want of a common collecting centre being very obvious.

[1] Alexander v Humboldt supported them, and was instrumental in giving to the Assembly at Berlin in 1828—which he called "The invasion of philosophers"—a special importance. It was, as he says, "a noble manifestation of scientific union in Germany; it presents the spectacle of a nation divided in politics and religion, revealing its nationality in the realm of intellectual progress."—Bruhns, 'Life of A. v. Humboldt,' vol. ii. p. 130. The British Association for the Advancement of Science was (as Prof. Owen informs us) at the outset avowedly organised after the Oken-ian model.—'Encyclopædia Britannica,' art. "Oken."

[2] The first reports aiming at giving a statement of the position of Science were those drawn up by Delambre and Cuvier at the request of the Emperor Napoleon I., and presented in the year 1808 under the title 'Discours sur les Progrès des Sciences, Lettres, et Arts depuis 1789 jusqu'à ce jour' (1808). They were imitated on a larger scale by the Emperor Napoleon III., on the occasion of the great Paris Exhibition 1867, and have been continued under the Republic. Of the report of 1808 Cuvier says, "Ce tableau historique nous servira désormais de point de départ et nos rapports annuels en seront autant de continuations." He also adds significantly, "Dans les relations actives où nous nous trouvons avec la plupart de ceux qui cultivent les sciences, il est bien difficile qu'ils se fassent en Europe quelques découvertes importantes sans que le bruit en retentisse promptement dans cette enceinte, et nous excite à des travaux qui s'y rapportent plus ou moins directement."

By far the most important work of reporting and summarising the results of scientific labour has been done by Germany. The first publication of this kind, however, originated with Berzelius, who from the year 1821 reported regularly to the Academy of Stockholm on the progress of the physical sciences. Of Berzelius's periodical Kopp says ('Geschichte der Chemie,' vol. i. p. 403), that it "summarises with the greatest completeness all that had been done in chemistry since 1820." This work, which regularly appeared in German translation, was continued in Liebig's 'Jahresbericht der Chemie' (1847). In Berlin the 'Physikalische Gesellschaft' has

sciences, in which all scientific researches are—without regard to nationality—reviewed, classified, and arranged in the most complete manner, according to the place which they occupy in the general development. Invaluable service has also been done in England by special Reports or Addresses, prepared by men of the greatest eminence—frequently at the request of the British Association—in which the position of special branches of science is explained, the work of the past summed up, the leading principles clearly brought out, and the unsolved problems placed prominently before the minds of young and aspiring workers.

In Germany during the first half of the century a reaction set in against the metaphysical treatment of scientific subjects, which had been exaggerated in the schools of Schelling and Hegel. Experimental research, following mainly the great French and English models, was next favoured, and through the establishment of laboratories and observatories, through voyages of discovery and the application of science to the industries, an enormous amount of detailed and minute knowledge was accumulated.[1] For a time—even within the limits

20 Reaction in Germany against metaphysical treatment of scientific subjects.

continued to issue regularly since 1845 annual Reports under the title 'Fortschritte der Physik.' But it was only in 1868 that a similar annual was started in Berlin having reference to mathematics, under the title 'Fortschritte der Mathematik.' A 'Jahresbericht' on Zoology has appeared ever since 1879, and one on Botany since 1873.

[1] It was the age which compiled the great repositories of chemical knowledge. Such were Gmelin's 'Handbuch der Chemie' (1st ed., 1817. Translated into English by the Cavendish Society, 1848), and the 'Handworterbuch der reinen und angewandten Chemie' (edited by Liebig jointly with Poggendorf and Wohler, 1837). The same age also set going and filled the volumes of Liebig's 'Annalen' (started by Hanle in 1823 under the title 'Magazin der Pharmacie,' it finally assumed the title of 'Annalen der Chemie und Pharmacie' under Liebig's editorship), of Poggendorf's 'Annalen der Physik und Chemie' (1824), and the 'Annales de Chimie et de Physique'

of exact reasoning—attempts to condense and unify knowledge were discredited. The result—especially in Germany—was that in many sciences information became buried in periodicals and in the memoirs of learned societies: text-books were chiefly written by men of secondary importance, translated from the French and English, and frequently on somewhat antiquated lines.[1] The new spirit which began to leaven scientific research in the middle of the century was confined to a few master minds, who—frequently almost unknown—marched in advance of their age. In the course of the last thirty years this has been entirely changed. The means of intercourse and communication, referred to above, make scientific isolation almost impossible; the necessity has been felt of remodelling the whole of the popular school literature on more modern lines: some of the first in-

21. Reform in school literature.

[1] The greater part of the higher German school literature in mathematics and physics was supplied by the French or modelled on French ideas—Legendre and Monge in elementary and descriptive geometry, Lacroix in the higher branches. Francœur's course of mathematics was introduced in England as well as Germany; Poisson, and later Lagrange and Duhamel, became the models in mechanics, Biot and Pouillet in experimental physics, Regnault in chemistry. The only great popular authorities which did not belong to France were Berzelius and Graham in chemistry, and Euler in mathematics. As late as 1860 hardly any text-book existed in Germany on the theoretical and mathematical portions of physics. The second volume of 'Baumgartner' was a miserable compilation. Beer's 'Hohere Optik' was the first important work of this kind. Germany had indeed not been wanting in original research, but the new ideas of Mobius, Steiner, Staudt, Plücker, and Grassmann in geometry found no adherents till, mainly through the translation of Salmon's text-books by Fiedler, a new spirit came over geometrical teaching. In the meantime Lejeune Dirichlet, and Neumann the elder, cultivated in their academical lectures the higher branches of mathematical physics, and educated a whole generation of mathematicians and physicists. Through them the original researches of Gauss and Jacobi became better known, and an independent school of German mathematical thought was established. In England the influence of French science was much more limited, and to the present day Euclid is preferred to Legendre's more elegant methods.

tellects in science have condescended to write text-books of their subjects, by which a great reform has been brought about in the higher scientific literature.[1] At the same time —after fifty years of experimental research and accumulation of material—it has become necessary to review the fundamental principles on which scientific reasoning rests: a more philosophical, not to say metaphysical, spirit is manifesting itself within the limits of science.[2] In the abstract, and especially the mathematical, sciences, real progress depends now mainly upon the discovery of methods of simplification, on conciseness and elegance of treatment, and on the discovery of unifying principles and generalising aspects.[3]

22. Scientific reasoning more philosophical.

[1] This remark refers mainly to England and Germany. In France, as a result of giving lectures at the École Polytechnique, the Bureau des Longitudes, the Faculté des Sciences, &c., the great mathematicians and physicists of the century have frequently worked up their researches in connected treatises For such we are indebted to Lamé, Cauchy, Poncelet, and many others. But the two works which in England and Germany created probably the greatest reform in the teaching of the principles of natural philosophy were Thomson and Tait's 'Natural Philosophy' (first sketch, 1863, 1st ed., 1867) and Kirchhoff's 'Vorlesungen über Mechanik' (Leipzig, 1877).

[2] I refer principally to the various writings of Helmholtz, following those of Riemann, and the many hints thrown out in Gauss's published papers, and in his correspondence with Schumacher. Helmholtz has—of all purely scientific writers —paid most attention to the metaphysical foundations of geometry and dynamics, and has critically examined the earlier theories of Kant, published a century ago It is interesting in this respect to note what Kant is reported to have said to Stagemann in 1797 "I have come with my writings a century too soon, after a hundred years people will begin to understand me rightly, and will then study my books anew and appreciate them." (See 'Tagebucher,' von Varnhagen von Ense, Leipzig, 1861, vol. i. p. 46.) Next to Helmholtz we are most indebted to Emil du Bois-Reymond and his brother Paul. See Emil's 'Reden' (Leipzig, 1886-87, 2 vols), and the posthumous work of his brother 'Ueber die Grundlagen der Erkenntniss in den exacten Wissenschaften' (Tubingen, 1890).

[3] An authority on this subject says. "Generality of aspects and methods, precision and elegance of exposition, have, since the time of Lagrange, become the common property of those who claim to be scientific mathematicians. This

All these are merely external signs of the new life, indications of progress and change: the inner reason and result, the altered ways of thinking which underlie or are produced by these external changes, will be the object of closer study hereafter; they constitute the real substance of this work. What I draw attention to here, by way of introduction, are merely fingers on the dial-plate of a complicated clock-work: their motion and position are patent to every one. Later on I shall invite the reader to remove the outer case, and try with me to understand the delicate working parts and the principle of the mechanism, the prime mover and the mode of transmission of motion within. The general curiosity that exists to follow the internal and hidden workings of thought is manifested especially in that country which in modern history has frequently taken the lead in philosophical reasoning. It is manifested by the huge and increasing historical literature of Germany, which is devoted to tracing out the growth and development of modern science and thought. In that country history seems for the moment to have taken the place of metaphysical speculation. A similar transition from the logical to the historical view can be traced in English literature in the last century, the

23. Germany has taken the lead in studying the life of thought.

generality is sometimes exaggerated at the expense of simplicity and usefulness, and then leads to abstruseness and to the enunciation of theorems which have no special application; precision may degenerate into an affected brevity which renders a dissertation more difficult to read than to write; elegance of form has in our days almost become the test of the value of a theorem. Yet in spite of all drawbacks these conditions of efficient progress are of the greatest importance, inasmuch as they keep the scientific matter within those limits which are intrinsically necessary if mathematical research is not to lose itself in minutiæ or be drowned in over-abundance." — Hankel, 'Die Entwickelung der Mathematik in den letzten Jahrhunderten' (Tübingen, 1869).

typical representative of that change being David Hume, who, starting with the metaphysical problems involved in Locke's and Berkeley's writings, was from them led on to the study of moral, political, and economic questions, and ended by devoting himself to the study of history.[1] At the end of his career political and historical writings were as frequent in English literature as metaphysical and theological writings had been at the beginning. The causes which have effected the same transition from the metaphysical to the historical mode of treatment in Germany during the present century are similar to those existing in England in the last century; but the whole movement has taken place on a larger scale, penetrates deeper into the mental life and work of the nation, and cannot be so easily studied in the writings of any great representative.

24. Causes of transition from metaphysical to historical method.

Whilst in Germany historical studies are now foremost,

[1] I am quite aware that generalisations of this kind must be made and used with great caution. I therefore refer my readers to Leslie Stephen's 'History of English Thought in the Eighteenth Century,' especially to the Introduction, where the typical position of Hume is fully discussed, and also to the last chapter of the second volume, where he says of Hume (vol. II. p. 381, 1st ed.). "Hume was, in one sense, far in advance of his time, and indeed of the average opinion of the present time But the change may in many respects be described as a revolt from Hume's opinions, much more than a development of them. . . The history of philosophical and of theological opinion in England is a history of gradual decay down to the revolutionary era" And p. 444. "The last half of the century was pre-eminently historical. As civilisation progresses, as records are better preserved, and a greater permanence in social organisation makes men more disposed to look beyond their immediate surroundings, a tendency to historical inquiry is naturally awakened. This cause alone, without the more philosophical considerations which might lead a Hume or a Gibbon to turn from abstract investigations to historical inquiries, may account for the growth of antiquarianism in the latter years" But the mere statistics of English literature in the eighteenth century suffice to prove the decline of argumentative and the growth of realistic literature.

and have almost dislodged systematic philosophy, England has for the first time in her history produced a system of philosophy—that of Mr Herbert Spencer; and this with the distinct understanding that the object of philosophy is the unification of knowledge[1] It is a remarkable fact, which will occupy our close attention hereafter, that the unifying principle in this system is historical,—a process of development now specially known under the term Evolution. This system forms in a certain way a contrast to the last great system in German philosophy, that of Hermann Lotze Whereas in all systems of evolution the unity of things is historical, and has to be sought in their common origin, Lotze emphasised the truth that unity must be a living presence, a principle which exists in individual things, not merely a link which connects them by proximity in time or space. His object is to answer the question, How can the human mind represent to itself such a living unity, in what ideas

25. Herbert Spencer the first Englishman who has produced a system of philosophy.

26. Definition of Lotze's system.

[1] See G. H. Lewes ('Problems of Life and Mind,' 1st ed., vol. i. p. 84), who says: "The absence of a philosophy in England during the last two hundred years has been a serious defect in her culture. Science she has had, and poetry and literature, rivalling when not surpassing those of other nations. But a philosophy she has not had, in spite of philosophic thinkers of epoch-making power. Hobbes, Locke, Berkeley, Hume, have produced essays, not systems. There has been no noteworthy attempt to give a conception of the world, of man, and of society, wrought out with systematic harmonising of principles. There has not been an effort to systematise the scattered labours of isolated thinkers. Mr Herbert Spencer is now for the first time deliberately making the attempt to found a philosophy." And in his 'History of Philosophy' (3rd ed., vol. ii. p. 653) the same author says: "Mr Spencer alone of British thinkers has organised a system of philosophy." Croom Robertson would take exception to this in favour of Hobbes, "who attempted a task which no other adherent of the 'mechanical philosophy' conceived—nothing less than such a universal construction of human knowledge as would bring Society and Man within the same principles of scientific explanation as were found applicable to the world of Nature" (Ency. Brit., 9th ed., vol. xii. p. 39).

belonging to human thought can this unity be grasped, by what words of human speech can it be expressed?

Both Mr Herbert Spencer's 'System' and Lotze's 'Microcosmus' are written with the object of establishing the unity of thought, of preserving the conviction that things exist and that events happen in some intelligible connection, and especially that the religious and the scientific views of the world and life are reconcilable. But whereas Mr Spencer is content to point to the underlying unity as the Unknowable, and then betakes himself to the study and exposition of the manner in which events follow and things develop, Lotze considers the whole of this part of philosophy as merely an introduction to the solution of the real problem. To him a process of development is merely the outer form in which some real substance presents itself, a mechanical method by which something of higher value is accomplished. He admits the all-pervading rule of such a mechanism, but he urges the necessity of finding the substance itself, and of gaining a view of the end and aim which is to be attained by this array of processes, by this parade of mechanical means, of the interest that attaches to them, and the result which is to be secured.[1] Knowing the mechanism by which a certain object is accomplished, we may be able to calculate phenomena and events, but to understand[2] them requires a

[1] The earliest passage in which Lotze gives us a pretty complete idea of his philosophical methods and aims is to be found in his polemical pamphlet against Fichte the younger ('Streitschriften,' Leipzig, 1857, p. 52 *sqq.*) He there also reviews his attitude to the idealistic school of German Philosophy and to Herbart, whose follower he refuses to be called (*ibid.*, p 5 *sq.*) It is evident that at that time his system was not yet definitely settled in his mind (p. 58).

[2] The difference between calculating and understanding phenomena is probably to be traced to Leibniz. Lotze emphasises this difference.

further knowledge of the worth of the object which is accomplished, of the result which is gained by the calculation. It is one thing to be able to trace the mechanical conditions upon which the accuracy of a clock depends; it is another to mark the hour which the clock strikes, and to note the time which it measures out to us for our work. Curiosity will lead a child to pry into the former; but the latter depends on our appreciation of the objects of life and the seriousness of our duties.

27 Lotze's relation to Herder's 'Ideen'

When Lotze undertook to write the 'Microcosmus,' he referred to two great works of a kindred tendency. Both attempted, yet in very different ways, to give a comprehensive view of a large field of scattered phenomena, to take in at a glance the entire scheme of a great world of facts. The earlier of the two belonged to the last century and was concerned with history, with the uniting bond of all human development. For this Herder, in his 'Ideen zur Philosophie der Geschichte der Menschheit,' had, if not invented, yet endowed the term Humanity with a specific pregnancy, meaning by it the unity of all human interests in their social and historical development—an idea which since Leibniz has governed German literature.[1] The other

See, *inter alia*, the closing paragraph of the first volume of the 'System der Philosophie' (1st ed., Leipzig, 1874). I cannot omit to notice here the extraordinary and misleading misprint in Erdmann's quotation of this passage: see his valuable 'Geschichte der Philosophie' (3rd ed., Berlin, 1878, vol. ii. p 861), where instead of *berechnen*, to calculate, we read *bezeichnen*, to designate!

[1] The history of this idea has been written by Hettner in the last two volumes of his 'Literaturgeschichte des 18ten Jahrhunderts.' I quote from the 2nd edition, Braunschweig, 1872. Herder had inherited the spirit of Leibniz (see, *inter alia*, the concluding chapter of my essay on Leibniz, in Blackwood's Philosophical Classics, Edinburgh, 1884). Herder formed a kind of centre of thought, inasmuch as he gathered up in his own mind and writings the influences of Leibniz, Rousseau, and the English writers of the eighteenth cen-

great work was that of A. v. Humboldt, who in the course of a long career, peculiarly favoured by opportunities for studying Nature on an extensive scale, and for appreciating the detail of modern research, of which he was an illustrious representative, had never lost sight of the all-pervading unity.[1] In an elevated style, in which poetry and science

28. Lotze's relation to A. v Humboldt's 'Kosmos'

tury, together with classical influences and new inspirations drawn from the popular song-literature of all nations Hettner says (see last volume but one, p 7). "Herder applied Rousseau's gospel of Nature to the demands of poetical sense and creation. Thus he has become essentially the forerunner of the new school of poets the last fetters of the moralising style by which even Lessing was still hampered fell, and through the scientific study of the beginnings and development of human culture he became the founder of a new science of Language, Religion, and History, in the lines of which we are still advancing." And p 101 · "Herder does not belong to the classics of the style of Winckelmann, Lessing, Kant, Goethe, and Schiller; he is everywhere only suggestive, hardly anywhere conclusive and final. For this reason his writings are to some extent antiquated Nevertheless Herder is one of our most important and influential spiritual heroes Herder made so deep an impression on his age that the great poetry of Goethe and Schiller, the so-called Romantic School, the philosophies of Schelling and Hegel, cannot be imagined without Herder as the precursor" The fourth volume of Gervinus, 'Geschichte der deutschen Dichtung,' contains likewise a very important chapter on Herder. But the great authority on Herder is R. Haym, 'Herder nach seinem Leben und seinen Werken' (Berlin, 2 vols, 1880 and 1885) From the unpublished literary notes, correspondences, and diaries of Herder, which Haym inspected, it is evident that the great idea of writing a History of Humanity originated in Herder's mind as far back as the year 1769, on a voyage from Riga to Nantes (on the way to Paris). His diary closes thus: "History of the progress and of the powers of the human mind in the concurrence of whole ages and nations—a spirit, a good demon, has exhorted me to do this. Be that my life's work, History, work!"

The first attempt to carry out his great idea was published by Herder in the year 1774, with the title: 'Auch eine Philosophie der Geschichte zur Bildung der Menschheit.' Herder was then in his thirtieth year. His chief work appeared ten years later (1784), with the title 'Ideen zur Geschichte der Menschheit' Herder died in 1803. Goethe's 'Faust,' which is an attempt to deal with the highest problems of human interest, the problems of knowledge, evil, sin, and redemption, as they appear in the history of a great individual, not of the race, had its first beginnings about the same time as Herder's 'History of Mankind.' But the work was not finished till a year before Goethe's death in 1831

[1] Alex. v. Humboldt, 'Kosmos. Entwurf einer physischen Weltbeschreibung,' 1845. Like Herder's great work on the 'History of Humanity' and Goethe's 'Faust,' Humboldt's 'Kosmos' occupied a

are happily blended, he essayed in the evening of life to unroll before the gaze of his readers a picture of the grand features of nature as his mind had viewed them from the elevated regions of scientific study, and his eyes from the heights of Chimborazo.

29. Lotze's 'Microcosmus.'

In the great picture of the world, in the vast changes of the universe, where is man with his life and his interests? In the huge Kosmos where is the Microcosmus? This question naturally presented itself to the mind of Lotze. "It is not," he tells us, "the all-embracing 'kosmos' of the universe which we wish to describe again on the model which has been given to our nation. As the features of that great world-portrait sink deeper into general consciousness, so much more vividly will they lead us back to our own selves, suggesting anew the question, What significance belongs to man and human life with its lasting characteristics and the changing

long period in the life of its author. Goethe's 'Faust' deals with the individual problem, Herder's 'Ideen' with the problem of the race or mankind, Humboldt's 'Kosmos' with the same problem as referring to the world, the universe. In the preface Humboldt confesses "that the image of his work had stood before his mind's eye in undefined outlines for nearly half a century": *cf.* what Goethe says in the dedication to 'Faust' (written probably after 1797):—

"Again ye come, ye hovering forms, I find ye
As early to my clouded sight ye shone,"
&c.
—Transl. B. Taylor.

The view of the universe which was given in Humboldt's 'Kosmos' was prepared by his own publication, 'Die Ansichten der Natur' (1808); also by Georg Forster (1754-1794), who wrote an account of the second voyage of Captain Cook round the world, whom he accompanied with his father. "He conceived of nature as a living whole; his account is almost the first example of the glowing yet faithful description of natural phenomena, which has since made the knowledge of them the common property of the educated world" (R. Garnett in 'Ency. Brit.,' art. "Forster"). Humboldt confesses to have received from him "die lebhafteste Anregung zu weiten Unternehmungen" ('Kosmos,' vol. i. p. 345, also vol. ii. p. 65, and especially vol. ii. p. 72, where incidentally also Darwin's narrative of the "Adventure" and "Beagle" is mentioned).

course of its history in the great totality of nature?"[1] And in collecting the answers to this question which suggest themselves both in and outside of the study, Lotze professes only to renew the enterprise brilliantly begun by Herder in his 'Ideen zur Geschichte der Menschheit.' Both Herder's 'Ideen' and Humboldt's 'Kosmos' belong to the age in which philosophy and poetry largely influenced science and history. Many may now think it premature or altogether impossible to try to combine the detailed studies of modern science and modern history with the comprehensive view demanded by philosophers and poets, or to grope through the labyrinth of external phenomena and events to their underlying significance and unity. They may, whilst fully maintaining the existence of an all-pervading power, nevertheless relegate it with Mr Spencer to the region of the Unknowable.[2] Without desiring at present to

[1] Microcosmus, 1st ed., Leipzig, 1856, Preface. Hermann Lotze was born in 1817, and died in 1881. His first philosophical essay of importance was the 'Metaphysik' (Leipzig, 1841).

[2] Herbert Spencer's Philosophy of the "Unknowable" is laid down in his Introduction to 'First Principles.' I believe the first appearance of the first part of this book was in 1860, and the first collected publication in the year 1867. In defining the region of the Knowable an opposite course has been adopted by Emil du Bois-Reymond, who in a series of addresses and articles, now collected in two volumes with the title 'Reden' (Berlin, 1886 and 1887), tried to lead up to the limits which are fixed around scientific knowledge The purport of his teaching on the highest "World-problem" is contained in the four words, *ignoramus*, *ignorabimus*, *dubitemus*, *laboremus*. The first of these addresses, which are full of brilliant suggestions and vivid illustrations, furnishing in the notes especially an invaluable store of historical references on the subject of the philosophy of the sciences, was delivered at the forty-fifth meeting of the German "Naturforscher und Aertze," and published at Leipzig, August 1872, with the title 'Die Grenzen des Naturerkennens.' It made a great sensation, and was translated into several languages. It was followed some years later by an address delivered in the Berlin Academy, 1880, and published with the title 'Die sieben Weltrathsel.' If H. Spencer's philosophy is termed the philosophy of the Unknowable, Du Bois-Rey-

criticise the weighty considerations which have led them to a view so modest and resigned, I propose in the sequel to test within narrower limits, and by what seems to me a novel method, the validity of the conviction that a true understanding of phenomena and events can be attained only by viewing them in their interdependence and collective effect. If anything in the wide expanse of physical and mental life deserves to be considered as one and indivisible, it is surely human thought in its various branches and manifestations. The attempt to trace its origin in the early ages of civilisation, or to foreshadow the end which it is slowly approaching, may indeed be impossible; but of the age to which we belong, and the literature of which we have witnessed the growth, we may claim to possess a deeper knowledge. Astronomers have succeeded in gaining a view of immense and distant orbits by minutely observing and tracing merely an insignificant portion[1] which came within their view. Comparative anatomy teaches how from a few surviving links to construct the whole framework of an organism. I propose to apply a similar method to the small portion

mond's may be termed the philosophy of the Limits of the Knowable. Both views form a contrast to Lotze's philosophy.

[1] The most brilliant example of this is the discovery of the planet Ceres by Piazzi at Palermo in the New Year's night of 1801; the invention of special methods for calculating the orbit of this planet, which had been lost, by Gauss in the course of 1801; and the rediscovery of it by Olbers, aided by Gauss's ephemeris, in the New Year's night of 1802. After the discovery of this first of the small planets, but before it was known in Germany, Hegel published his 'Dissertatio philosophica de orbitis planetarum,' in which he ridiculed the search for new planets, but which Duke Ernest of Gotha sent to the astronomer Zach with the superscription, "Monumentum insaniæ sæculi decimi noni." See R. Wolf, Geschichte der Astronomie, Munchen, 1877, p. 684 *sqq.*

of mental progress of which I have been able to take personal notice and of which I have felt the immediate personal influence. A tracing as concisely as possible of this comparatively small portion of the course of European thought may be the first approximation to more accurate delineations, which themselves will be the means of gradually gaining a truer idea of the purport and significance that belong to the larger dimensions of the mental life of mankind.

This life does not consist in the accumulated knowledge of our century, not in the results of scientific inquiry deposited in libraries and museums, not in the many schools for learning and study, not in educational and social reforms, least of all in political and economic institutions. These are all external objects, which are capable of being described or photographed like the external objects of nature. The mental life of mankind consists in the inner processes of reflection, by which these external objects have been produced, by which man has been able to add to the physical creation of nature a new creation of his own, by which he has been able to change the face of the earth, and endow the objects of nature with an ideal meaning. To this end he is always inventing and using methods which change, suggesting and applying principles which turn out to be half true or totally fallacious, guessing at results and aims which have to be abandoned, inventing theories which are short-lived—in fact, erecting scaffoldings with the help of which he raises the structures of Society, Art, and Science: these remain as the historical testimonies of his activity, the scaffoldings are removed as of merely transient and temporary value; and yet they

30. What the mental life of mankind consists of.

alone constitute the mental life which interests us. Only so far as we have taken part in building the scaffolding, only in so far as we have witnessed the many contrivances which have been used, only in so far as we have seen the growth of any structure from small beginnings, from the first sketch of the architect, can we say that we know something of the mental life which lies hidden in and behind those external signs and documents. A closer study of what we ourselves have witnessed is thus the only way of attaining some insight into the workings of the mind—the spiritual life of mankind. We shall presently find that in science as well as in philosophy every period starts from certain assumptions and proceeds according to certain methods, that certain habits of thought become general, and certain views become accepted; but in the course of one or two generations we find those assumptions questioned, those methods criticised, a new habit of thought introduced, and those general views which seemed so natural and convenient giving way to new and altered ones. The whole fabric of society, the whole structure of science and knowledge, all the applications of art, have to be remodelled on new principles, and to meet our changed demands. Few indeed, very few, of the old creations remain. One or two so-called laws of science that survive, a few dozen books that are re-edited, half-a-dozen works of art and one or two great poems,—this is about all that our century will at its close have preserved as the living inheritance of its early years: all the others will be relegated to the growing bulk of historical records. Possessed of merely monumental interest as documents of a bygone life, these creations had to be left aside as incap-

31. Methods, the most approved, have their day, and cease to be.

32. One century does not inherit all of the past, it discards much.

able of marking or guiding any longer our onward career. A few centuries lapse, and posterity will look upon them as we do on the huge monuments of early Eastern civilisation, on the Sphinx in the desert or the Pyramids of Egypt, wondering by what ingenious contrivances they were raised, what amount of human work and suffering they represent, or what idea lived in the minds of those who planned and placed them where they still remain.

III.

1 Necessity of choosing a road.

It is the privilege of art to represent at a glance the whole of its object, and thus to produce at once a total effect on the mind of the beholder. Closer scrutiny may follow and may show how the various parts support the whole, how the uniting idea is revealed in all the manifold detail of the component elements. still the impression of the whole remains and supplies the key for the comprehension of every part Literature, science, and history are denied this privilege of presenting their objects in their entirety, and thus giving from the outset a commanding view, a leading and abiding impression of the whole. We have to ask the student to follow us patiently by an isolated path to the summit: many ways lead to it, and we may err in the choice of the right and convenient one. Even if we succeed in reaching the central position, we may have fatigued the reader on the road or produced sensations which prevent the unbiassed contemplation of the whole view when it is presented. With us the whole is only the sum of its many parts, whereas with the artist the parts are merely fractions of a united whole. In

treating of the thought of the century, even within the narrow limits which have been prescribed, I am met with similar difficulties. In the large circumference of the domain of thought I have to choose a starting-point and to construct a road which may lead to the central position, hoping there to gain a comprehensive view of the whole.

2 Some periods of history take their name from some great event or movement

Some periods of history are characterised by one great and central movement which absorbs all active forces and all intellectual and imaginative power, making them either subservient to one end and purpose, and helpful in the elaboration of one idea, or else forcing them into opposition, where they testify equally to the importance of this central movement. Such periods were, for instance, the long centuries of Jewish history, the early age of the Christian Church, the period of the culmination of Papal power, the Reformation, the French Revolution. In studying the thought of such ages, we are not at a loss where to find the leading idea,—we easily fix the centre of the vortex which draws into its motion all the existing forces, all genius and all talent. In an age like that of the Reformation we can speak of the Politics of the Reformation, the Religion of the Reformation, the Philosophy, Literature, and Art of the Reformation, and we are pretty sure to embrace under these various heads an account of all the mental progress and to trace all the thought of that age, be it friendly or antagonistic. It is evident that no such central event, no such all-absorbing vortex of motion, exists in the period which we have lived through. The uniting bond, if it exists, lies much deeper; the problem we have been engaged in solving, the prize we are fighting for, does not present itself on

3. No central event in our age.

the surface, it is not explicitly stated, it must be implied rather than defined. The great object of our life and labour has not been clear to us, as it seemed clear to those who lived during the Reformation or the Revolution, otherwise we should not have philosophies of the Unconscious and of the Unknowable, and the century would not end in asking, Is life worth living?

Then, again, we find in history long periods of quiet development, where men's minds seemingly run very much in the same direction, exhibiting a general tendency of ideas, the spreading of a defined habit of thought and of simple methods, the application of a few principles. such a period was that preceding the French Revolution, the greater part of the eighteenth century. It has therefore been easy to characterise that century · it has been termed the philosophical century, the century of the *Aufklarung*, the century of Voltaire.[1] No such one

[1] The first who reviewed the literature of the eighteenth century from an international point of view was Villemain, who as early as 1820 was engaged in lecturing at the Sorbonne before the *élite* of the rising literary generation of France on the literature of the eighteenth century, taking France as the centre, and showing the influence of foreign literature, especially English, as likewise the reaction of French ideas abroad. He was too early to recognise the true meaning of the new spirit which had then already gone forth from Germany In this respect his 'Cours de Littérature française,' published in 1828 and republished in 1864, remains incomplete Schlosser next attempted to present in his 'Geschichte des achtzehnten Jahrhunderts,' after the manner of Gibbon, a picture of the combined political and literary work of the last century The first draft of it appeared in 1824, after Schlosser had passed two years in Paris, where no doubt he must have come under the influence of Villemain. The work itself began to appear in 1826, and was finished in 1848. It is considered to be Schlosser's greatest work, and had a large circulation. The connection of political and literary history was studied by Gervinus, who with Hausser is usually counted as a pupil of Schlosser. But the great work which Villemain had begun and Schlosser taken up was adequately carried out by Hettner, who in his 'Literaturgeschichte des achtzehnten Jahrhunderts' conceived the whole intellectual movement of that age as a battle for enlightenment (*Kampf der Aufklarung*). The

term can be applied to our age, no one name can be found which carries with it the recognition of all the many interests which surround us.

4. Is history of thought history of philosophy?

It has been suggested by some that the history of thought is equivalent to the history of philosophy; that the different philosophical systems and theories exhibit in the abstract the course which ideas have taken in an age.[1] A history of thought in the nineteenth century would thus mean a history of nineteenth century philosophy. There have indeed been plenty of philosophies and systems during our period, but in spite of their great number and variety—ranging from the extreme idealism of Fichte to the equally extreme materialism of Buchner[2]—we feel that they do not cover the whole area of thought. The period in our century which in England was most barren in philosophy, the first forty years, produced an entirely new literature and a novel conception of art, both containing new sources of mental life, though they have hardly yet found expression in any philosophical system. Equally barren in speculation was France during the Restoration; yet there, too, was a

latter part of his work deals with the reaction against *Aufklärung* and "Rationalism" as it began in England, and was represented on the Continent by Rousseau and the earlier ideals of the French Revolution. Through Rousseau and the Revolution the growing influence of the new spirit of English literature was overpowered and lost for the Continent. And, as we have to regret in Villemain his neglect of the new life of Germany, so we have to deplore that Hettner followed the developments of Rationalism and *Aufklärung* only in the form they assumed in Germany, neglecting to notice the contemporary growth of the new life in English Literature and Art, to which, in fact, no German historian has as yet done justice.

[1] See especially Hegel's Lectures on the History of Philosophy in his collected works, vol. xiii. p. 68 *sqq.* (Complete edition, Berlin, 1832.)

[2] The principal publications of this school are Vogt, 'Physiologische Briefe,' 1845-47; Moleschott, 'Der Kreislauf des Lebens,' 1852; Buchner, 'Kraft und Stoff,' 1855.

brilliant era of literature, and the whole of Europe was illuminated by the light of science which emanated from Paris during the first third of this century. History of philosophy has little to say about Goethe, though his work embodies for us probably the deepest thought of modern times. Again, the only great and novel system of philosophy which France has produced during this century is that of Comte, but it has had only small influence in its own country; and who would say that it reflects French thought of the period as Voltaire and Montesquieu reflected the thought of the last century? Hegel himself, who was intent upon tracing the working of the human mind in the systems of philosophy, declared that philosophy is the latest fruit of civilisation,—that the special idea which governs any period is already dying out when it appears in a system.[1]

5 Goethe's work involves the deepest thought of the century.

[1] The principal passage expounding this idea of Hegel's is to be found in the introduction to the course of lectures which he delivered at Berlin repeatedly during the years 1816 to 1830. See his collected works, vol. xiii p. 66: "Philosophy makes its appearance at the time when the mind of a nation has worked itself out of the indifferent dulness of the early life of nature, as well as out of the period of passionate interest; inasmuch as the direction towards detail has spent itself, the mind transcends its natural form—it passes on from practical morals, from the force of real life to reflection and comprehension. The consequence is, that it attacks this actual form of existence, these morals, this faith, and disturbs them; and with this comes the period of decay. The further stage is, that thought tries to collect itself. One may say, that where a people has come out of its concrete forms of life, where distinction and separation of classes has set in, where the nation approaches its fall, where a rupture has taken place between the inner desires and the external reality, where the ruling form of religion, &c., &c., does not satisfy, where the mind shows indifference towards its living existence or lingers discontentedly in it, where moral life is in dissolution—then only does one philosophise. The soul takes refuge in the realms of thought, and in opposition to the real world it creates a world of ideas. Philosophy is then the reparation of the mischief which thought has begun. Philosophy begins with the decline of a real world when she appears with her abstractions, painting grey in grey, then the freshness of youth and life is already gone; and her reconciliation is not one in reality, but in an ideal world."

6. Philosophy retrospective.

This means that philosophy is retrospective: it sums up, it criticises, it does not prefigure the future. The correctness of this proposition may be doubted. We shall have to deal with it in another place. At present it reminds us that thought, in the sense in which we take it, cannot be identified with philosophy, and hence a history of philosophy in the nineteenth century is not identical with a history of its thought. There is indeed a sense in which the word philosophy is sometimes used, when it approaches more nearly to the meaning of the word thought, as we intend to use it. Whewell has in this sense written the philosophy of the inductive sciences, meaning to trace in that work the processes of thought which are consciously or unconsciously employed in scientific research and reasoning, and which lead to progress in science. Something similar might be attempted in regard to art, commerce, politics, government, religion, and literature generally. In every case philosophy would simply mean the peculiar way of thinking and reasoning which is adopted in these various branches of practical or intellectual life. This is, however, not the sense in which the word philosophy is generally used. It generally denotes something more than a statement of method or a *rationale* of ideas and reflections; it denotes a definite theory, an explanation of a larger or smaller circle of phenomena. As such it certainly forms a part of the thought of the century, probably the most interesting and fascinating part; but it is also that which is most liable to change, most subject to discussion; whereas the other more hidden thoughts and reasonings form, as it were, the ground upon which all the

7. When does thought mean philosophy?

intellectual, artistic, and practical achievements of the age rest.

8. Inquiry into thought of the century divided into two questions

It would thus appear as if an account of the thought of the century might naturally divide itself into two separate investigations. In the first place, we should regard thought merely as a means to an end, as the method adopted to attain a certain purpose, be it practical or theoretical. It would mean the peculiar kind of reasoning which has been employed in the search for knowledge or in its useful application. As all reasoning starts from certain assumptions, called premisses, or principles, or axioms, and progresses from these by certain methods, this portion of our task would divide itself again into a statement of the principles which underlie, and an account of the methods which have guided, theoretical and practical reasoning. But thought does not exist merely for the sake of increasing our knowledge of things and of applying this to practical purposes. Occupied in this way merely, it remains fragmentary, incomplete, and not infrequently it reveals contradictions. Even those who devote themselves purely to detailed research or to practical work are again and again compelled to take a wider and deeper view of things than their special occupation affords. One may find that the methods which he is using daily become useless for certain practical purposes he has in view, and may thus be forced to question the principles which during half his lifetime he has applied with unquestioning faith in their validity and usefulness. Another may have met with such success in the use of a special method of research, that he wishes to apply it to subjects which were previously handled in a different manner, or elevate it to

the dignity of a general rule of thought. A third may, accidentally, be interested in two or more pursuits which are seemingly unconnected, but which—being brought side by side in his mind—he feels the wish to unite and harmonise. A fourth may, at a certain time of life, grow tired of the drudgery of petty pursuits which never carry him beyond a very limited sphere of interests: he is tempted to look beyond this narrow range, and gain some wider view of other pursuits and interests. Allowing that ignorance or indifference prevents even the majority of those whose powers are not exhausted in the struggle for mere existence from looking much beyond their narrow circle, allowing also that many of us live—like children—in a blessed trust that the great and important interests of mankind are under higher and better guidance than we can understand or control, there still remain a considerable number of persons who are always on the look-out for something higher, wider, and better, who are driven by an undying thirst after real wisdom, or by an

9 Speculation

inherent restlessness of disposition to inquire into the deepest foundations and the ultimate ends of the world and life. Language has coined a word which denotes the whole of these occupations and endeavours, how various so ever they may be, and for whatsoever purpose they may be undertaken. It calls them speculations. The word also indicates the venturesome and risky nature of these undertakings. They have existed in all ages and countries and languages wherever literature has existed, and have been carried on by the powers of reason or imagination, in prose, verse, or symbol, sometimes in defined and clear terms, more often in mystic allegory. Philosophy may be

said to have grown out of these vague and scattered beginnings by the attempt to conduct them according to some method, and to unite them into a complete and consistent whole. Philosophy may thus be defined as speculation carried on according to some clear method, and aiming at systematic unity.[1] Both science and philosophy may be called methodical thought, but the word system is applicable only to the higher and more advanced forms of philosophic thought which aim at unity and completeness.

10 Philosophy defined

We have thus arrived at a second division of our subject. In the first we have to consider thought merely as a means to an end; in the second we have to consider it as its own object, as a reflection on itself, carried on with the object of knowing its own origin, its laws, its validity, of testing its powers, and with the end and aim of gaining certainty, completeness, and unity. The whole of this great division of thought I shall comprise under the

11. Division of the book.

[1] This view of the nature and object of Philosophy agrees with Lotze's definition (see 'Grundzuge der Logik,' Leipzig, 1883, § 88): "The *common culture of life* and the *separate sciences* contain a number of suppositions the origin of which is obscure to us, because they have been very gradually formed within us through the comparison of many experiences, or because they have first become conscious by means of such experiences, have then received definite names and become habitual without having been subjected by us to any examination as to the reason, the sense, and the extent of their validity. In this way science and life make use of the notions of *cause* and *effect*, of *matter* and *force*, of *means* and *end*, of *freedom* and *necessity*, of *matter* and *mind*, and they frequently entangle themselves, owing to the above-mentioned defect, in contradictions, inasmuch as they are unable to fix the limits of validity of these to some extent contradictory assumptions.

"Now we may formally define the task of Philosophy as follows: that it is an endeavour to import unity and connectedness into the scattered directions of cultured thought, to follow each of these directions into its assumptions and into its consequences, to combine them all together, to remove their contradictions, and to form out of them a comprehensive view of the world; mainly, however, to subject those ideas which science and life regard as *principles* to a special scrutiny, in order to determine the limits of their validity."

term Philosophy; and as the first part will deal with the scientific, so will the second deal with the philosophical thought of our century.

Science has gradually risen out of the mass of accumulated but inaccurate and disorderly knowledge by the desire of making it accurate, orderly, and useful. Philosophy has similarly emerged from the great world of speculative thought by the desire of carrying it on methodically and for a defined end and purpose. Nevertheless neither the one nor the other, nor both together, really exhaust the whole meaning of the word "Thought"; neither science nor philosophy covers the whole region of thought. Both are comprised under the term methodical thought; but there remains the great body of immethodical, undefined thought. This is buried in general literature, in poetry, fiction, and art; it shows its practical influence in the artistic, moral, and religious life of our age. It is a reflection of the knowledge of science or the light of philosophy, but, like all reflected light, it not only follows, it also precedes the real and full light: it is not only the dusk that comes after, it is also the dawn that comes before the day, it is the twilight of thought. In it lie hidden the germs of future thought, the undeveloped beginnings of art, philosophy, and science yet unknown and undreamt of; it encloses and surrounds the innermost recesses of the mind, where all thought had its origin, and whence it ever and again draws fresh life and inspiration.[1]

12 Neither science nor philosophy comprises the whole meaning of the word thought.

13. Thought also hidden in the literature and art of the age.

[1] This is originally a Leibnizian idea. It is laid down in the doctrine of the *petites perceptions*, as given in the introduction to the 'Nouveaux Essais,' and referred to in many passages of Leibniz's various

No account of the thought of our century would be complete or satisfactory which took no notice of this great volume of immethodical and unsystematic thought which lies buried in the general literature and in the art of the age. Both have shown a vitality, originality, and versatility which exceed that of any except the few favoured periods—those of Athens under Pericles, Italy during the Renaissance, and England under Elizabeth. In one of the arts, in music, our age has, according to the opinion of many competent judges, exceeded in originality and certainly in productiveness all former ages. In poetry Goethe and Wordsworth have raised our tastes and demands to a higher level, in fiction France and England have almost created a new branch of literature, whilst the peculiar features of modern English landscape-painting were unknown to previous centuries. All this, though produced under no scientific or philosophical rule

14. Goethe and Wordsworth raised our tastes.

writings. See 'Nouv. Ess.,' Preface, Leibniz, Philosophische Werke, ed. Gerhardt, vol. v p. 48:—

"Ces petites perceptions sont donc de plus grande efficace par leur suites qu'on ne pense. Ce sont elles qui forment ce je ne sçay quoy, ces gouts, ces images des qualités des sens, claires dans l'assemblage, mais confuses dans les parties, ces impressions que des corps environnans font sur nous, qui enveloppent l'infini, cette liaison que chaque estre a avec tout le reste de l'univers. On peut même dire qu'en consequence de ces petites perceptions le present est gros de l'avenir et chargé du passé, que tout est conspirant (*σύμπνοια πάντα*, comme disoit Hippocrate) et que dans la moindre des substances, des yeux aussi perçans que ceux de Dieu pourraient lire toute la suite des choses de l'univers.

"Quæ sint, quæ fuerint, quæ mox futura trahantur. . . . C'est aussi par les perceptions insensibles que s'explique cette admirable harmonie préestablie de l'âme et du corps, et même de toutes les Monades ou substances simples, qui supplée à l'influence insoûtenable des uns sur les autres, et qui au jugement de l'auteur du plus beau des Dictionnaires exalte la grandeur des perfections divines au delà de ce qu'on eu jamais conçu."

The importance of this idea of Leibniz has been dwelt on at length by Kuno Fischer in his 'Geschichte der neueren Philosophie,' where he also traces its influence in the development of philosophy and literature in Germany after Leibniz.

and very frequently outside of any school, points to novel modes of mental conception, to a fund of ideas yet undeveloped or only partially developed into clear thought. The whole of this productiveness indicates a vast amount of mental work which, though not yet absorbed by science or philosophy, belongs nevertheless, according to our original conception, to the world of thought. The meaning of it may be enigmatical, and the clear expression which it will some day produce in philosophical and scientific reasoning may be far distant and unintelligible to us now. Still there it is, this great body of undefined thought, this volume of diffused light, the focus and centre of which is still hidden from us. We feel that in discussing the thought of the century we cannot pass it by or neglect it.

15. Unmethodical thought.

It is difficult to find any one term under which we could comprise this great body of unmethodical, scattered, and fragmentary thought,—any one word, similar to science and philosophy, in which we could sum up and characterise its general meaning and tendency. So far we have only stated what it is not, what to a large extent it perhaps never will be—*viz.*, methodical. And yet we feel that it contains that kind and portion of thought which touches our deepest interests, our most intimate concerns, our noblest aspirations. Science becomes more and more a mere calculation, *une question d'analyse*, an occupation for the laboratory, the workshop, the manufactory, and the market; philosophy savours at its best too much of the school and lecture-room, runs too much into systems and categories, it fatigues us with definitions

and abstractions. But neither calculation and measurement, nor definition and abstraction, suffice to exhaust what is to us, in the quiet and serious moments of life, of the deepest concern—*viz.*, our religion. I use the word here in its original sense, and I propose to sum up in the term religious thought the whole of the thought contained in that large volume of literature which does not submit to scientific and philosophical treatment, but which nevertheless forms so important an outcome of the mental life of the century.

16 Summed up in the term religious thought.

There are other words more or less current in modern literature that may serve to throw some light on the distinction that I am here drawing for the purpose of affording a preliminary view of the course to be pursued in the following treatise.

Science is said to be exact, positive, and objective, and it is opposed to such other thought as is inexact, vague, and subjective. Science is said to convey its results or ideas in defined, direct, and general terms, whereas there is a large department of literature and thought which moves in undefined, symbolical, and indirect expressions. Science professes to rest on clear and precise knowledge, and is thus opposed to such other realms of thought as rest on opinion, belief, and faith. It may be well to note here that these different terms refer either to the method of treatment or to the matter which is under treatment. Science alone professes to have a rigid and undisputed method. Other branches of thought either borrow their methods from science, or they have fluctuating, not generally recognised methods, or they refuse to submit to method

17 Science is exact, positive, and objective.

altogether. But so far as the matter under treatment is concerned, a clearer division is possible. Science deals with all such things or objects of thought as are common to a great many persons and—under certain circumstances—are accessible to everybody: it thus claims that its observations and reasonings can be checked and submitted to repeated examination and verification; so that a large portion of them can always be regarded as settled and agreed upon, and can be taken for granted and used as a secure foundation by those persons who are themselves unable or unwilling to go through the process of verification. But there are a great many things and interests which centre in the individual mind of each person—which are, in fact, personal, individual, or subjective. They are to all of us just as important as the others. They form the real subject-matter of all that thought which is separated from science, and in its very nature and aspect opposed to it. In this great province of thought one person cannot do the work for many in the same way as is possible in science. Proof is almost impossible, and agreement refers always only to a certain number of persons. Doctrines or theories in this region of thought cannot be accepted and taken for granted as they are in science, but every person must go over the same ground for himself before he has any right to accept or make use of what is given to him. The real and true character of all this thought is that it is individual and personal, whereas all scientific thought—whatever its origin may be—must be general and impersonal. At the extreme end of thought in one direction are placed the mathematical sciences, at the extreme end in the other lies religion. Disagreement in the former is

18. Some interests or objects of thought are personal or subjective

19 Agreement on these matters impossible.

almost as unknown[1] as agreement in the latter. There we have an almost universal unity of thought; here unity of thought probably never existed, it is unknown. Popularly we can say that at the one extreme lie knowledge and certainty, at the other faith and belief. There is, however, a very large extent of ground between these two extremes. This is covered by all such intermediate thought as rests partly on knowledge, partly on faith, where certainty is largely mingled with belief. This large intermediate region, where changes and fluctuations are frequent and rapid, is the proper home of philosophy, which occupies itself with the grounds of certainty and belief, the origin of knowledge and faith, and the relations in which both stand to each other. Were all our thoughts either purely mathematical — *i.e.*, referring to number, measurement, and calculation, or purely religious—*i.e.*, referring to our individual concerns and personal convictions,—the need of a continued compromise or mediation would be unnecessary, the question as to the grounds of certainty or belief would never arise. But no sooner do we wish either to apply our strict mathematical notions and processes, or to bring our personal convictions into practical use, than the two kinds of thought come into contact, not to say into conflict, and there is need of some theory according to which this contact may be regulated, this conflict settled. And as the occasions for such contact change with the demands of practical life, or

20 Philosophy intermediate between mathematical science and religion

[1] It may be doubted whether this is quite correct, looking at the controversies which have been connected with many mathematical theories—such as the theory of parallel lines, the meaning of infinitesimals, the correct measure of force. These controversies, however, referred really to applied, not to pure mathematics, and were settled by introducing correcter and more stringent definitions.

the progress of applied science, these theories must themselves change and develop. Now it may be generally stated that it is the task of philosophy to take note of these different ways by which the strict methods of science are applied and made useful, or by which personal and individual convictions are brought to bear upon practical questions which are not only of personal but of general interest and importance. It does not follow that philosophy must necessarily construct a complete system, but it is a natural and frequent occurrence that the occupation with a great number of detached theories or aspects of thought generates the desire to bring them into harmony and to unite them in a connected whole. Thus the enterprise which was originally purely critical and preparatory, and undertaken merely as a means to an end, may lead to the formation of a general and all-embracing view of things —*i.e.*, to a philosophical system.

21. Threefold consideration of thought. scientific, philosophical, individual

From whichever side we approach the matter, we are thus always led to a threefold consideration of thought, as scientific, as individual, and as philosophical. An attempt in which any of these three aspects were neglected could have no value in an account of the thought of our age. There have indeed been schools of thought which identified science with philosophy, or which maintained that no independence belonged to religious, personal, or individual thought, inasmuch as this was merely of a derived character. Though such theories may have exerted considerable influence, they have as a whole failed,[1]

[1] This can be said of Hegelianism as well as of Comtism. In the former it was a favourite doctrine that philosophy was the higher wisdom compared with religion and art. See Hegel, 'Geschichte der Philosophie' (Werke, vol. xv. p. 684): "The highest aim and interest of philosophy is to reconcile thought, the idea, with reality.

and we find ourselves at the end of a long and critical period unable to say that any one of the three realms of thought has gained an undisputed victory over the others. Science is more than ever that kind of thought which gives knowledge and certainty. Religion is still the generally recognised abode for those convictions which refer to our deepest personal interests. And more than ever do we feel the need of a reconciliation of both in some theory of life which is neither purely scientific nor purely individualistic; and this means that philosophy is as much needed as ever. Our century has witnessed a great development of scientific thought, a great revival in religious interest, religious feeling, and religious activity, and it is probably richer than any preceding age in philosophical theories and systems.

22 Philosophy the mediator between science and religion.

I must repeat here what I said above, that it is a misfortune that in dealing with a complicated subject we are obliged to divide it,—that we are forced to give preference to some one aspect, and to choose a special

Philosophy is the veritable theodicy, compared with art and religion and their sentiments—this reconciliation of the mind, indeed of that mind which has grasped itself in the freedom and wealth of its reality. It is easy otherwise to find satisfaction in subordinate regions of intuition and feeling," &c., &c. Although it is an exaggeration to say that Hegel desired to absorb or evaporate religious belief in philosophical knowledge, as his lengthy explanation (Introduction to the 'History of Philosophy,' Works, vol. XIII. p. 77 *sqq.*) sufficiently proves, there is no doubt that the sentiment expressed in the above passage indicates that philosophy was coming to the rescue of true religious belief, which threatened to be lost in the rationalistic and mystical schools of the day. And this had the further consequence that a scientific occupation with or interest in religious subjects—be it metaphysical or historical—took the place of a purely religious interest, and that many eminent German theologians became either pure metaphysicians or merely critics, the practical side being lost sight of.

It is probably just as incorrect to accuse Comte of an intention to destroy true religion because he preached the well-known doctrine of the three stages of human thought—the theological, the metaphysical, and the scientific or positive.

point from which to set out. In dealing with the thought of our age, I have been obliged to divide what is in reality connected and coherent; and I am further forced, in examining more closely its different aspects, to select one as the most prominent with which to make a beginning. In reality such a preference does not exist in my plan. I recognise all the aspects of thought as equally important, and I feel that I might begin with any one of the three, and that I should in due course be led on to a consideration of the other two. They are in their actual historical appearance in the course of our period so interwoven that they cannot practically be separated. And it is indeed not difficult to assume various positions in contemplating the whole subject from which either one or the other of the three forms of nineteenth-century thought assumes as it were the ascendancy. Thus it would be undeniable that from a German point of view the great movement of ideas centred in the first third of the century in what I have called philosophy. The number of systems which succeeded each other was astonishing, the influence they had on literature, science, and practical life was without precedent, the enthusiasm with which students from all parts gathered in the lecture-rooms of the great metaphysicians was quite extraordinary, and probably equalled only in the schools of Athens in antiquity, or in the lecture-room of Abelard in the middle ages. From this point of view an account of this great movement—how it grew, flourished, and died away—would no doubt afford a suitable introduction to the history of thought in our century. If after this we were to turn to France and try to fix upon the

28. Difficult to separate the three aspects of thought.

most striking intellectual feature of the century, it would be the equally great and remarkable array of scientific names of the first magnitude. In France during the early part of the century the foundation of nearly all the modern sciences was laid; many of them were brought under the rule of a strict mathematical treatment. It was there that scientific subjects were made so popular, and clothed with a garment of such elegant diction, that they have since that time greatly entered into general consciousness, and have promoted in literature and art an independent school — the naturalistic. Compared with this mathematical and naturalistic spirit, philosophy proper has found but a meagre development and culture in France: the constructive tendency of idealism has found nourishment for the most part only in leanings to the older systems of Descartes, Plato, and Aristotle, or to the foreign ones of Hegel and other German metaphysicians. Compared with Germany in philosophy, and with France in science, England during the early part of the century appears remarkably unproductive. English science and English philosophy had flourished in the seventeenth and eighteenth centuries, and leavened the whole of European thought, but in the beginning of our period we find neither represented by any great schools. The great discoveries in science belonged to individual names, who frequently stood isolated; the organisation and protection which science could boast of in France was then unknown in England; into popular thought it hardly entered as an element at all. Metaphysics had not recovered from the blow which David Hume had struck, and speculation was confined

24 French thought centred in science during the first part of the century.

25 State of philosophy in the early part of the nineteenth century in England.

almost entirely to the novel field of social and economic problems. But against this there was a young growth of ideas springing up in the poetic literature of the nation. It is the freshness of individual thought as clothed in the poetic language of Shelley and Wordsworth, maturing and deepening in the works of Tennyson and Browning, which strikes us as the most original phase of English thought in this century, whether we compare it with Continental thought of the same period, or with English thought of the previous age.

26. Goethe's 'Faust' representative of the thought of the century.

And lastly, we might be tempted to make the great work of the greatest mind of the early part of our period, Goethe's 'Faust,' the centre and beginning of our survey, singling it out as a comprehensive embodiment, as the classical expression of nineteenth-century doubts and aspirations, leading us—if we try to understand it—now into the bewildering labyrinth of philosophy, now into the cheerful expanse of natural science, and again into the hidden depths of individual life, of religious faith with its mysteries of sin and redemption.

But from whatsoever point we may start on our journey, from whatsoever easily reached eminence we may cast a first eager glance across the wide country which we wish to explore, there is one feature which impresses itself alike upon our minds from the very beginning. It is not a country of repose and restfulness, of healthy industry and quiet work, of gradual development, of ripening crops, of sowing or ingathering; it does not present the aspect of a happy division of labour, of successful co-operation, of peaceful regulation of employment. It looks more like a land which has lately been disturbed by

27. A period not of repose but of ferment.

great elemental forces, heaved up by an earthquake or visited by a destructive storm. We see some persons employed in filling up great breaches and recently made rents, others trying to lay new foundations; others again are fighting for their possession or trying to divide a disputed territory; even the peaceful workers are called out to help in the battle, or disturbed by the complaints of their neighbours, on whose ground they are trespassing unawares, whose foundations they are unconsciously undermining. If we inquire into the cause of this unrest and anxiety, which seems to be a feature common to nearly all the phases of nineteenth-century thought, we must look back to the age which immediately preceded it. It is the storm of the revolution which passed over Europe, and shook to the foundation all political and social institutions, that has likewise affected our ideas and thoughts in every direction. The period we refer to has thus not incorrectly been termed a century of revolution. If in spite of this I decline to consider nineteenth-century thought as essentially revolutionary, it is because the work of destruction belongs in its earlier and more drastic episodes to the preceding age. The beginning of our period witnesses everywhere the desire to reconstruct, either by laying new foundations or by reverting to older forms of thought and life which it tries to support by new arguments or to enliven by a fresh interest and meaning. We may say that the thought of the century in its practical bearings is partly radical, partly reactionary,—meaning by the former all those constructive attempts which try to go to the root of things and to build up on newly prepared ground; by

28 Cause of it seen in the century of revolution preceding it.

29 Nineteenth-century thought not revolutionary.

30 Thought of this century partly radical, partly reactionary

the latter all those endeavours which, clinging to historical institutions and beliefs, aim at finding the truth and value which are in them, and the peculiar importance which they may have for the present day. The work of destruction is indeed still going on; in the midst of this constructive or reconstructive work we still witness the workings of the revolutionary spirit. The healthy new life which Burns, Wordsworth, and Coleridge infused into English poetry at the beginning of our period was disturbed in its quiet growth by the revolutionary spirit of the Byronic school. The new thought, which grew up in Kant's philosophy and the idealistic school, degenerated in its further development into a shallow materialism and a hopeless scepticism. But none of these destructive influences, however passingly interesting they may have been, seem to have struck out any new line of thought. Whoever wishes to study the arguments by which social order was subverted and cherished beliefs destroyed will find them brilliantly and consistently expounded in the writers of the eighteenth century, from which many nihilists of our age have drawn their inspiration. This is not the task which I have in view. It has been performed in our time by many writers of great eminence. Nor do I intend to describe the courses which governments and politicians have taken in dealing with the legitimate demands of the people, such as a hundred years ago found a memorable expression in the American Declaration of Independence, and an exaggerated one in the cry of the French Revolution. Only to a small extent has the ideal of that great movement, as it lives in the mind of many a democratic leader, been realised in our century. In

31. The thought of Burns, Wordsworth, and Coleridge disturbed by the Byronic school.

32 Destructive spirit in writings of eighteenth century.

most European countries the work of national unification and consolidation, and the struggle for political independence, have retarded internal reforms; nor have theorists been able to agree in what form of social organisation liberty and equality could consistently live side by side. Their teaching must indeed command special attention as one of the many forms of the philosophic thought of the age; but a wide gap separates theory from practical politics, which have been largely occupied with wars and diplomatic feats, or, when they really dealt with social problems, have had to be content with awkward compromises between prejudices and institutions of bygone ages on the one side, and legitimate demands for freedom on the other.

33. Revolutionary theories not practical.

Though much practical thought and much labour have been spent in achieving even these moderate results, I feel that they really fall outside of my programme. Wherever either science or philosophy steps out of the quiet regions of the study, the lecture-room, and the laboratory, or wherever religious faith leaves the secret recesses of the believing soul to solve the problems of life or to perform the work of the day, the line is crossed which I have felt obliged to draw around the following sketch. Not that I do not recognise this borderland, where the spirit subdues matter, where thought becomes useful, where the idea attains reality, this field of strife and endeavour, of patient toil and slow victory, as by far the most important subject of history, and as that in which our age has probably excelled every earlier period. But an account of this side of nineteenth-century life could ill afford to limit its view to the three principal countries of the Old World. For where are discovery and invention at this moment more at home

than in America; where have political theories, the original rights of man, the ideas of liberty, equality, and brotherhood, been more widely put to the test, where have religious beliefs entered into closer contact with the work of the day; or where in our age has the simple rule of early Christianity been more successfully put into practice? An account of the application of thought taken merely from our European experience, where half our endeavour must always be spent in clearing away obstacles, in removing the *débris* of antiquated institutions, in overcoming prejudice, or battling with evils which have grown to uncontrollable magnitude, would give us but a poor notion of the influence of thought over material circumstances, and a very exaggerated one of the inertia of the mechanism of older societies. With the work of the inventor, the practical statesman, or the lawgiver, I have thus nothing to do at present; only in cases where practical problems have immediately reacted upon scientific research, or where social questions have given rise to special theories, shall we be compelled to cast a glance outside of the inner world of thought into which I invite my readers to retire.

34. This is not a history of invention or of practical politics.

This inner world has, indeed, not been all rest and peace and quiet development. No age has been so rich in rival theories, so subversive of old ideas, so destructive of principles which stood firm for many ages, as ours. It is not my intention to emphasise this critical or radical tendency more than is necessary. True to the original view which I have already expressed, I intend to look upon thought as a constructive, not a destructive agency; on the world of ideas as a positive acquisition, not as a mere counterpart

35. Thought to be considered in its constructive, not in its destructive attitude.

or shadow of material existence. Though demanding for its growth an outer stimulus, and unable to proceed very far without external correctives, I nevertheless maintain that the human mind in its individual and collective life encloses an independent source of reality which contact with outer things and thought in all its various forms has to reveal, to preserve, and to develop. To what extent this has been done in our century is the question I propose to answer. With this object in view I shall try to gather my observations and my narrative around the prominent and novel constructive ideas which have sprung up in the course of the century, not omitting the great development which the purely formal side of thought, the method of research, has undergone. Such constructive ideas are those of energy, its conservation and dissipation, the doctrine of averages, statistics, and probabilities, Darwin's and Spencer's ideas of evolution in science and philosophy, the doctrines of individualism and personality, and Lotze's peculiar view of the world of "values" or "worths." Around these centres of thought cluster the many critical oppositions, the great controversies of radical or conservative opponents. As regards these, I shall welcome all radicalism which lays bare the roots of our ideas, which delves deep into the ground of our opinions and principles, or which points out new methods by which we may test the correctness and consistency of our axioms. As such I consider the spirit infused by Kant into all modern thought. That other radicalism, which merely roots up, which destroys without building, which fails to find any ground of certainty, simply because human thought and observation may after

36 Darwin's, Spencer's, and Lotze's constructive ideas.

37 The right sort of radicalism.

all be a delusion,—this kind of radicalism I shall try to pass over as meaningless. And equally meaningless appear to me those opposite conservative tendencies which merely annul progress, which shut out the daylight, and preach the doctrine of inertia. But this, again, will not prevent me from recognising the real gain and interest which belong to some reactionary movements, such as lay at the bottom of Romanticism, with its love of the past, its artistic idealisation of the childhood of mankind, of aspects of life in their infancy and primitiveness, with its study of mediævalism and its more sober historical tastes. I shall endeavour always to ask what addition to the great stock of human ideas has resulted; what gain we have to register; convinced that everything that lives must grow, increase, and multiply: and what can be more living than Thought?

38. Reactionary movement of Romanticism.

But although the school of Critical Thought in Kant, and the Romantic school as centred in Walter Scott and the German Romanticists, are in time almost the first intellectual phases of the century, they will not in the beginning command my special attention.[1]

[1] In order to give some idea of the complexity of the different currents of thought in the first years of the century, I place here a carefully selected list of dates. They refer to events or publications which mark epochs or important stages in the history of thought. Of specifically *scientific* importance are—

1796. Laplace's 'Exposition du Système du Monde.'
1799. (2 vols.)—1825. Laplace's 'Mécanique céleste.'
1799. Legendre's 'Théorie des Nombres.'
1801. Gauss's 'Disquisitiones Arithmeticæ.'
1801. Piazzi discovers and
1802 Olbers rediscovers the first of the minor planets, "Ceres," being assisted by Gauss's new methods of calculation, which were published *in extenso* in
1809. Gauss's 'Theoria motus corporum cœlestium.'
1798. Cuvier's 'Tableau élémentaire d'Histoire naturelle.'
1800-5. Cuvier's 'Leçons d'Anatomie comparée.'

Though somewhat later in point of time than they, the school of exact research seems to have become the more generally recognised agent in nineteenth-century progress.

1809. Lamarck's 'Philosophie zoologique.'
1799. Volta constructs his first electric pile, and announces this in
1800 to Sir Joseph Banks.
In chemistry the early years of the century brought many of Gay-Lussac's important Memoirs, in
1801 Humphry Davy publishes the first of his electro-chemical discoveries, and
1802-3 Berzelius publishes his own.
1803. Berthollet's 'Essai de Statique chimique'
1810. John Dalton's 'New System of Chemical Philosophy.'
1801. Thomas Young announces to the Royal Society his belief in the undulatory theory of light, which during
1802, 3, and 4 he substantiates further in his papers, and fully expounds during
1802 and following years in his lectures to the Royal Institution
1808. Malus announces his discovery of the polarisation of light through reflection.
1802. Chladni's 'Akustik'
Count Rumford's papers, which laid the foundation of the mechanical explanation of heat, belong to the end of the last century, and in
1799 H. Davy publishes his equally important 'Essay on Heat, Light, &c'
1800. Bichat's 'Recherches physiologiques.'
1801. Bichat's 'Anatomie générale'
1799-1804. Alexander von Humboldt travels in America, and lays by his observations the foundation of the sciences of physical geography and meteorology.
For the history of the *philosophical* movement of thought the years
1793-1806 witnessed in Germany the great development, expansion, and criticism of Kant's ideas in the writings of
1793 Schiller, 'Briefe uber asthetische Erziehung.'
1796. Schiller, 'Über naive und sentimentalische Dichtung.'
1797. Fichte, 'Wissenschaftslehre.'
1797. Schelling, 'Naturphilosophie.'
1803. Schelling, 'Transcendentaler Idealismus.'
1799. Schleiermacher, 'Reden uber die Religion.'
1800. Schleiermacher, 'Monologen.'
1799. Herder, 'Metakritik'
1799. Jacobi, 'Offener Brief an Fichte.'
1806. Hegel, 'Phanomenologie des Geistes.'
In France—
1804. Destutt de Tracy's 'Idéologie' represents the reigning philosophy, and
1803 Maine de Biran's 'Mémoire sur l'Habitude' the beginning of the later reaction against it.
In England—
1792-1827. Dugald Stewart's 'Elements of the Human Mind' and his

To it are due the great changes in every department of science, of life, and probably also of literature and art, the great inventions and the great conflicts of our age. Science has not only very largely influenced our ideas, it has also by its applications altered the external face of the world we live in. It is therefore simply a tribute to the popular view, and a desire to start from some striking and generally conceded position, if I select the scientific movement of ideas as the first with which I have to deal. How has it spread in the course of the century? From what beginnings and through what influences? What are its principles and methods? How have they themselves changed and developed? What has it led to? These are some of the questions which

39. Scientific progress to be considered first.

1803 'Life and Writings of Thomas Reid' represent the predominant Scottish philosophy, and
1804 Thomas Brown, 'Inquiry into the Relation of Cause and Effect,' the beginnings of the later associationalist school. At the same period Jeremy Bentham's influence, which cannot be reduced to special dates, had already acquired European if not world-wide importance. His long life (1748-1832) was contemporary with Goethe's (1749-1832), whose 'Faust' was given to the world in successive stages between the years 1790 and 1832.
1794. Thomas Paine's 'Age of Reason.'
1798. Malthus's 'Principles of Population.'
Literary criticism started on a new era and extended its influence in
1802 through the 'Edinburgh Review,' and
1808 the 'Quarterly Review'; in Germany somewhat earlier in
1794 Schiller's 'Horen.'
1797. Schiller and Goethe's "Xenien" in the 'Musenalmanach.'
1798. Schlegel's 'Athenæum.'
1802. A. W. v. Schlegel's Berlin lectures.

The *Romantic school* of fiction dates in Germany from 1798, when Frederick Schlegel uses the term for the first time as characteristic of a new departure in his review of Goethe's 'Wilhelm-Meister' ('Athenæum,' vol. i.) A literary movement with frequently similar aims and characteristics is represented in this country by Walter Scott ("Lay of the Last Minstrel," 1805), Southey ("Thalaba," 1802), and Coleridge ("Christabel," 1806), and spreads later into France. As the great source of the new and original *poetic* inspiration of nineteenth-century poetry we have the "Lyrical Ballads," 1798, and besides 'Faust,' the other principal works of Goethe and Schiller (died 1805).

I shall try to answer as concisely as possible. This selection does not commit me to any theory on the value of the scientific view as compared with other aspects. Such theories will have to be dealt with in a later portion of the work. They have sprung up in the course of the last hundred years, partly as the inevitable outcome of scientific progress itself, partly in the educational world, where a reaction has set in against the undue importance which former generations attached to classical learning and training. I need not at present do more than note these opinions, nor need I define my position with regard to Comte's celebrated positivist theory on the advancing stages of the human intellect. Curiosity and the consensus of popular opinion suffice for the moment to make me take up the scientific side of the thought of the age. As we proceed, other directions and movements will present themselves, and the interdependence of all human interests will reveal and explain what truth attaches to Hegel's celebrated doctrine of the inherent dialectic of ideas, the spontaneous development of thought.

40. Hegel's doctrine of the spontaneous development of thought.

A HISTORY OF EUROPEAN THOUGHT IN THE NINETEENTH CENTURY

PART I.

SCIENTIFIC THOUGHT

CHAPTER I.

THE SCIENTIFIC SPIRIT IN FRANCE.

1 Our century the scientific century

IT will be generally admitted that the scientific spirit is a prominent feature of the thought of our century as compared with other ages. Some may indeed be inclined to look upon science as the main characteristic of this age. The century may thus be called with some propriety the scientific century, as the last was called the philosophical century, or as the sixteenth was termed the century of the Reformation and the fifteenth the century of the Renaissance. It is therefore natural that we should begin our study of the thought of the age with an examination of this side of modern culture.

It is not necessary to *define* what I mean by science.[1]

[1] The use of the word science and its adjective scientific has varied considerably in the English language. We must wait for Dr Murray's great work to give us a history of the word. I venture to assert that it acquired its present definite meaning about the time of the formation of the British Association for the Advancement of Science (1831) The two other great organisations which professedly started for the culture of what we now call science—*viz.*, the Royal Society for the Improvement of Natural Knowledge, and the Royal Institution—did not use the word officially in their charter or title, although it is used frequently in the documents and correspondence connected with the foundation of the younger, and occasionally in those referring to the older Society. The Royal So-

Schools and colleges of science, triposes, examinations, and degrees in science, have established a popular meaning which did not exist a hundred years ago, but which is now well understood. For my purpose it is of some interest to note that the meaning of the word in French is somewhat different, and that the word *Wissenschaft*,[1]

ciety, and sometimes the Royal Institution, use the word "philosophy" in formal and official statements of their object. This is in accordance with older English usage. What we now universally call science was not infrequently termed in the seventeenth century natural knowledge, and Bacon himself translates *scientiæ* by "knowledge," by "learning," and sometimes by "sciences." In France, on the other hand, the word "science" seems to have acquired its present meaning as far back as the middle of the seventeenth century. At the time of the foundation of the "Académie des Sciences," in 1666, the word was used almost in the same sense — embracing the same separate departments of knowledge—as the word "science" is now used in this country when we speak of a college of science. In France, so far as I am aware, a cultivator of science has never been called a philosopher. Science and philosophy have there never been synonymous. But science in France has been made to cover a larger field of knowledge by such adjectives as "moral," "social," "political," and has been narrowed by such other adjectives as "exact" and "natural," in the same way as the word philosophy has been more strictly defined in the English language by the adjectives "natural," "experimental," "moral," "mental," &c. At the head of the sciences in France stood "mathematics," at the base of the new philosophy in England stood "experiment" and "observation"

[1] The word *Wissenschaft* has a much wider meaning than science in the modern sense, and is the literal translation of the Latin *scientia*. It means knowledge in a systematic form and connected by some method. What the French call *science*, the Germans call *exacte Wissenschaft*. This includes mathematics and *Naturwissenschaft*, which covers the ground covered by the word "sciences" in English. The word *Wissenschaft* plays an important part in German culture, as we shall see later on. The modern term "scientist" is about synonymous with the word *Naturforscher* in German. The word *savant* in French has no synonym in English, but is about equivalent to the term *Gelehrter* in German; and this, again, is partially translated by "scholar" in English. I suppose "man of science" and "scholar" together would be about covered by either *savant* or *Gelehrter*. Those who desire to study the older and modern, the English and foreign, uses of the word science and other kindred terms, should read Bacon' English writings; Weld's 'History of the Royal Society' (1848, vol. i.); Bence Jones's 'The Royal Institution' (1871), Léon Aucoc's 'L'Institut de France' (Paris, 1889), Alfred Maury, 'Les Académies d'autrefois' (vol. i., Paris, 1864); and the correspondence in connection with the foundation of the British Associa-

by which science is translated into German, requires a qualification in order to cover approximately the same ground. These verbal differences point to differences of thought. Only since Continental ideas and influences have gained ground in this country has the word science gradually taken the place of that which used to be termed natural philosophy or simply philosophy. One reason why science forms such a prominent feature in the culture of this age is the fact that only within the last hundred years has scientific research approached the more intricate phenomena and the more hidden forces and conditions which make up and govern our everyday life. The great inventions of the sixteenth, seventeenth, and eighteenth centuries were made without special scientific knowledge, and frequently by persons who possessed skill rather than learning. They greatly influenced science and promoted knowledge, but they were brought about more by accident or by the practical requirements of the age than by the power of an unusual insight acquired by study.[1] But in the course of the last

2. Difference of English and Continental notions of science.

tion in Dr Whewell's 'Writings and Correspondence' by Todhunter (2 vols, London, 1876). I believe the word philosophy has lost the specific meaning which it acquired in the Baconian school, as much through the influence of French science on the one side as through that of metaphysics on the other. The latter emanated from Scotland, and from Germany through Coleridge. It reinstated the word philosophy in its original sense.

[1] Examples are plentiful. Not to speak of gunpowder and printing, which came earlier, we have later nearly all the great improvements connected with the manufacture of textiles, the fly-shuttle, the self-acting mule, the power-loom, the spinning-roller, invented by men of little or no scientific education The same is the case with the older metallurgical processes, the refining of copper and the introduction of cast-iron. Watt was one of the first who brought a trained intellect to his mechanical work. The Royal Society was started with the distinct purpose of cultivating such knowledge as has "a tendency to use", the Royal Institution still more so It is, however, still doubtful, view-

hundred years the scientific investigation of *chemical* and *electric* phenomena has taught us to disentangle the intricate web of the elementary forces of nature, to lay bare the many interwoven threads, to break up the equilibrium of actual existence, and to bring within our power and under our control forces of undreamed-of magnitude.

3. Relation of science and practical life.

The great inventions of former ages were made in countries where practical life, industry, and commerce were most advanced, but the great inventions of the last fifty years in chemistry and electricity and the science of heat have been made in the scientific laboratory: the former were stimulated by practical wants; the latter themselves produced new practical requirements, and created new spheres of labour, industry, and commerce. Science and knowledge have in the course of this century overtaken the march of practical life in many directions.[1] A confused

ing the history of the learned societies as well as the rare cases in which highest scientific genius is allied with practical skill in the same person, whether the cultivation of research for its own sake should not preferably be kept distinct from its hasty application. This is the view held by many great thinkers abroad. In England the opposite view has frequently impeded the progress of pure science.

[1] A few examples may suffice. The discovery by Oersted and Ampère of Electromagnetism (1819, 1820) led at once to the idea of electrical telegraphy: the first telegraph over considerable distances was constructed by Gauss and Weber (see 'Wilhelm Weber,' Breslau, 1893, p. 26, &c.) The artificial preparation of an organic substance by Wohler in 1828 led at once to many attempts at preparing expensive organic compounds—especially medical substances—by chemical synthesis. The occupation with this problem under A. W. Hofmann's instructions led Perkin in 1856 to the discovery of the first aniline colour (Mauvein, see 'Berichte der deutschen chemischen Gesellschaft,' No. 17, p. 3391). Leblanc's discovery how to make carbonate of soda from salt, for which a prize had been offered by the Paris Academy under Napoleon, led to the enormous development of the sulphuric acid industry in England and on the Continent. Liebig foretold in 1840 the recovery of sulphur from the waste of chemical works and the effect on the sulphur mines of Sicily, fifty years before this process was satisfactorily carried out (see Liebig's familiar 'Letters on Chemistry,' 1st ed., 1843, pp. 22, 31, &c.) But the greatest of all industries created in the laboratory was probably that of

picture of this latest stage of culture lived in the prophetic but essentially unscientific mind of Lord Bacon. But he did not sufficiently allow for the amount of patient scientific toil that was needed, nor for the time which the preparation of the instruments of research would require, nor for the necessity of destroying existing superstition and accumulated errors. All that has since been done by Newton and the great Continental mathematicians in the former, and by Bayle and Voltaire in the latter sense, Bacon had hoped to achieve at once by the new philosophy of fruit and progress. Such expectations were inevitably doomed to disappointment, though posterity has made amends by all but universally referring to him as the pioneer of modern thought,—as the herald of a new era of human civilisation.[1]

4 Foreseen by Lord Bacon.

making artificially the fertilising compounds required in common agriculture which followed on the publication of Liebig's famous work on 'Chemistry in its applications to Agriculture and Physiology' in 1840 (see Hofmann's Faraday Lecture of 1875, 'The Lifework of Liebig,' p. 15, &c.) Liebig also discovered and described in 1832 the properties of chloroform and chloral, fifteen years before Simpson introduced the first as an anæsthetic and twenty years before Oscar Liebreich discovered the physiological action of chloral (ibid., p. 101, &c.) Sir Lowthian Bell calculated, many years before the invention of the so-called basic process of making steel, the fertilising value of the phosphorus which was contained in the ironstone of Cleveland, and which then made it useless for the manufacture of high-class iron and steel. The great revolution in the theory of the steam-engine embodied in the work of Macquorn Rankine is to be traced back to the patient measurements by Joule of the mechanical equivalent of heat.

[1] A great controversy arose on this subject through the publication of Liebig's pamphlet in 1862, entitled, 'Francis Bacon von Verulam und die Methode der Naturforschung.' It was directed mostly against the exaggerated view taken by Macaulay in his celebrated essay. The fact is that Bacon, like Voltaire after him, was much more of an essayist and a man of the world than a patient labourer in any special field of research; he was more of a philosopher in a worldly sense (what the Germans call "ein Weltweiser") than a profound thinker. He misunderstood many of the great discoveries of his age, though he prophetically foresaw the great change in the spirit of inquiry. He did not appreciate

5 Defect in Bacon's philosophy.

Our age has in many ways inherited the spirit of Bacon's philosophy, but it would be a mistake to attribute its great scientific achievements to the exclusive working of this spirit. Bacon was neither a retired and patient nor an accurate thinker—the desire to apply and make his learning useful led him away from the "sapientum templa serena" into the forum of life: in his own experience, as well as in his writings, he anticipated many of the dangers which beset modern culture—the love of premature application, and the haste for practical results and achievements. Science, which in the hands of patient and diligent observers[1] had just been rescued from the sway of empty metaphysical and theological reasoning,

the enormous part which mathematics would play in the development of science. In this respect Descartes was a genius of much greater originality—his actual contributions to scientific progress, as well as those of Pascal, being far beyond those of Bacon; but they both retained the metaphysical habit of thought which has characterised many, if not all, among the greatest mathematicians. In modern culture the popularisation of novel views and ideas has become so important a factor that writers like Bacon and Voltaire, who combine the scientific and literary taste, are of the greatest importance in the diffusion of new ideas, though none of their works need be looked upon as great repositories of research and knowledge. Before Liebig wrote his pamphlet, a very impartial and temperate estimate of Bacon's philosophy and its relations to actual science was published by Robert Leslie Ellis in his introduction to the philosophical works of Lord Bacon (London, 1857). As the literature of the subject is so large, I cannot but recommend this essay as containing one of the best discussions of it.

[1] A very good and concise account of the achievements of these contemporaries and forerunners of Bacon—of Tycho (1546-1601), Kepler (1571-1630), Galileo (1564-1642), Gilbert (1540-1603), Harriot (1560-1621), Napier (1550-1617), Harvey (1578-1656)—is given by John Nichol in the second volume of his 'Francis Bacon, his Life and Philosophy' (Edinb., 1889), pp. 86, 254. In the same volume (p. 193) there is also a useful summary of Bacon's real claims to a place among physicists, of his ignorances (p. 196), and of the reception which his works met with in England and abroad (p. 233 to end). Not quite so readable, but more complete, is the little volume of Hans Heussler, 'F. Bacon und seine geschichtliche Stellung' (Breslau, 1889), with its flood of references—which exhaust the subject. See especially p. 160, &c., on Bacon's anticipations.

was in danger of falling a prey to hasty generalisation for the purpose of practical ends. Practical demands threatened then, as they frequently still do, to stifle or to force into premature growth the patient thought which had just begun to germinate in the new light and freedom of reason. The narrow view had indeed been widened, and the breadth of the land had been surveyed, but there was little inclination to deepen the view, or to do more than search on the surface. The spirit of Bacon's philosophy required a corrective. For a long time to come the hope of practical application had to be postponed; the thinker and student had to retire into solitude, and there to lay the more permanent foundations of the new research. This was done by Newton for all time. His reputation spread more slowly than that of the great High Chancellor; but it rests on a surer foundation, which baffles every attempt to shake it, and will outlast all coming changes of thought.

6 Corrected by Newton.

The beginnings of modern scientific thought are thus to be found in this country. Lord Bacon foretold prophetically the great change which the new philosophy was destined to work. Newton more patiently drew up the first simple rules and gave the first brilliant application. More than the unfinished and wearisome pages of Bacon's 'Novum Organum' does the 'Principia' deserve to be placed on a line with Aristotle and Euclid as a model work of scientific inquiry.

For a real recognition of the greatness of Newton, as well as for a partial realisation of Bacon's plans, we are, however, mainly indebted to the French philosophers of the second half of the eighteenth century. Bacon's plan of promoting

7 Bacon's and Newton's ideas taken up by French philosophers.

knowledge and research by the co-operation of many was more thoroughly realised in the old French Academy than in the Royal Society of London: his desire to unite all knowledge in a collective work underlies the great productions of Bayle, and still more those of the Encyclopædists. The many problems contained in Newton's 'Principia' were first treated singly by Clairault and Maupertuis; a general knowledge of his view of the universe was introduced into popular literature by Voltaire,[1] who made use of it as a powerful weapon wherewith to combat error and superstition, or, as he termed it, "pour écraser l'infâme"; but for a full announcement of its scientific value and its hidden resources we are indebted to Laplace, whose 'Mécanique céleste' was the first comprehensive elaboration of Newton's ideas, and whose 'Système du Monde' became the scientific gospel of a whole generation of Continental thinkers.

8. Bacon and Newton compared.

We may look upon Lord Bacon as one who inspects a large and newly discovered land,[2] laying plans for the

[1] I believe Voltaire was the author of the term *Newtonianisme*. The modesty and truly scientific spirit of Newton would not have allowed him to apply such a term to his work, and it is doubtful whether Voltaire did not extract from Newton's 'Philosophia Naturalis' a general philosophy which was not conceived in his spirit.

[2] Cowley in his Ode to the Royal Society —

"Bacon at last, a mighty man, arose,
And boldly undertook the injur'd pupil's cause.
. . led us forth at last,
The barren wilderness he past;
Did on the very border stand
Of the blest promis'd land;
And, from the mountain's top of his exalted wit,
Saw it himself, and shew'd us it"

On this Mr Ellis remarks (Bacon's Works, vol. I. p. 63): "Bacon has been likened to the prophet who, from Mount Pisgah, surveyed the Promised Land, but left it for others to take possession of. Of this happy image, perhaps part of the felicity was not perceived by its author. For though Pisgah was a place of large prospect, yet still the Promised Land was a land of definite extent and known boundaries, and, moreover, it was certain that after no long time the chosen people would be in possession of it all. And this agrees with what Bacon promised to himself and to mankind from the instauration of the sciences . . . In this respect, as in others, the hopes of Francis Bacon

development of its resources and the gathering of its riches. But the wealth lies deep down, and is only indicated by the first labours of the early pioneers. Newton, following these, unites their beginnings into a systematic exploration, and sinks the main shaft which reaches the lode of rich ore. He opens out the wealth of the mine and marks out the work for his followers. But many difficulties had to be overcome, much united effort and a vast organisation of labour were required, in order to develop to the full Newton's scheme, and to raise the great treasure which he had reached. This was not done until the end of the last century, when Laplace collected, arranged, and condensed the work of French and English mathematicians and observers into a picture of the universe. A variety of circumstances had combined to make the French capital the place above all others where the means and materials for the development of the great work could be most easily procured. Let us glance for a moment at the different factors in operation during the eighteenth century which contributed to the great achievement.

9 Laplace's work

Whilst Newton was labouring privately and almost unassisted[1] at the greatest scientific work produced in

were not destined to be fulfilled It is neither to the technical part of his method, nor to the details of his view of the nature and progress of science, that his great fame is justly owing. His merits are of another kind. They belong to the spirit rather than to the positive precepts of his philosophy."

[1] It has been stated that Newton, not knowing of Norwood's approximately correct determination of the length of a degree in 1635 (published in his 'Seaman's Practice' in 1637), but relying on the old figure of sixty miles for a degree of latitude (confirmed by Ed. Wright, Cambridge, 1610), was led away from the right supposition, which he entertained as far back as 1665, regarding the moon's orbit, and had to wait for Picard's figures (ascertained about 1669, published in France about 1672, and in the

modern times by any single mind,[1] the penetrating and far-seeing genius of Colbert had already recognised the important part which science would one day play in the government of the world, and had secured the approval of his royal master to the constitution of an Aca-

Philos Transactions in 1675), by applying which he determined that "the moon appeared to be kept in her orbit purely by the power of gravity." See Brewster's 'Life of Newton,' vol. i. p. 290, &c.; Todhunter's 'History of the Theories of Attraction,' vol. i p. 38, &c This account is, however, now discredited (see *infra*, chap. iv.) For the part which Dr Hooke and Halley took in the discovery of the "reciprocal duplicate" ratio, see also Brewster, *loc. cit.*, vol. i. p. 291, &c. During the writing of the 'Principia' Newton carried on a useful correspondence with Flamsteed, who was then Astronomer-Royal. How this happy co-operation ceased ten years later can be read at length in Brewster (*loc. cit.*, vol. i. p. 312; vol. ii. p. 164, &c.) The greatest material assistance which Newton received was from Halley, who defrayed the expenses of publishing the 'Principia,' after the Royal Society, to which it was dedicated, had reversed its resolution to defray them (Brewster, vol i. p. 305, &c.) Nevertheless Weld, in his 'History of the Royal Society,' says: "Fortunate indeed was it for science that such a body as the Royal Society existed, to whom Newton could make his scientific communications; otherwise it is very possible that the 'Principia' would never have seen the light." Though one must lament the differences between Flamsteed and Newton, which prevented the latter from bringing his investigations of the lunar and planetary theories to a close (Brewster, vol. i. p. 312), a word of deep gratitude is due to Flamsteed's own exertions in the cause of astronomy. After Charles II had built the Observatory in order to have the places of the fixed stars "anew observed, examined, and corrected for the use of his seamen" (Flamsteed, History of his own Life), and after he had appointed Flamsteed Astronomer-Royal at a salary of £100 per annum, the Observatory, "hurriedly established, was left for a period of nearly fifteen years without a single instrument being furnished by the Government" (Weld, vol. i. p. 255). The instruments were mostly supplied by Flamsteed himself or lent by others, and besides, "the king had ordered that Flamsteed should instruct monthly two boys from Christ Church Hospital, which was a great annoyance to him, and interfered with his proper avocations" (Baily, 'Account of the Rev. J. Flamsteed'). "Any other man would probably have succumbed under the amount of drudgery appertaining to the office (earning his salary by labour *harder than thrashing*), if indeed, in the absence of encouragement, he would have continued in it at all, and particularly when the reward was so insignificant" (Weld, vol. i. p. 256)

[1] "And it may be justly said, that so many and so valuable Philosophical Truths, as are herein discovered and put past dispute, were never yet owing to the Capacity and Industry of any one Man" (Words of Halley, Philos. Transactions, vol. xvi., 1687).

demy, which was based upon the endowment of research, and which prompted the co-operation of its members in organised[1] scientific work. Whilst the Royal Society of London only received a charter, and existed by the entrance payments and contributions of its own members, augmented by private donations, the Paris Academy had, as far back as 1671, received the funds with which to commence its labours in connection with the survey of the kingdom and its extensive dependencies. It was these labours which led to the measurements of the length of the seconds pendulum, and of the variation of gravity in different latitudes; to the explanation of this variation by Huygens, to the controversy regarding the figure of the earth; to the direct measurements of the arcs of the meridian in Peru and Lapland; and, finally, to Clairault's celebrated work on this subject.[2] It was almost exclusively by these observations that the data were found with which to substantiate Newton's mathematical reasonings: in his own country that fruitful co-operation which

10. French Academy of Sciences.

[1] "Le roi assurait l'existence des Académiciens par des pensions et mettait libéralement à leur disposition un fonds destiné à pourvoir aux frais de leurs expériences et de leurs instruments" (Maury, 'Les Académies d'autrefois,' vol. i p 13) Organisation and co-operation are difficult to obtain in societies founded on private and voluntary contributions. In England they scarcely existed before the foundation of the British Association, with perhaps one illustrious exception pointed out by Struve ('Description de l'Observatoire de Pulkowa,' 4to, Pétersbourg, p. 5): "Il y a, dans l'histoire de l'observatoire de Greenwich, un point très remarquable, savoir que les astronomes ont travaillé sur un même plan, depuis l'origine de l'établissement jusqu'à l'époque actuelle" Organisation and co-operation were the order in the Paris Academy from the beginning. "On y travaillait de concert", and, "Dès les premiers mois de 1667, Perrault proposa un plan de travail pour la physique, c'est à dire pour l'ensemble de l'histoire naturelle" (Maury, *loc. cit.*, p. 15).

[2] A full account of these is given in Todhunter ('Hist. of Theories of Attraction, &c.,' vol. i) Clairault's book was published in 1743, and had the title, 'Théorie de la Figure de la Terre, tirée des Principes de l'Hydrostatique, par Clairault.'

can only be secured by an academic organisation and by endowment of research was wanting No one since the time of Bacon had been more impressed with this necessary condition of modern progress than Newton's great rival, Leibniz,[1] much of whose time was spent in promoting academies all over Europe—in Berlin, St Petersburg, Dresden, and Vienna—and who had himself been early attracted to Paris and London by the scientific fame of their learned societies, though he significantly pointed out the want of activity and efficiency in the early history of the Royal Society.

11. Continental methods in mathematics.

There was, moreover, another and independent line of scientific thought which had centred in France, the development of which came greatly to the aid of the students of Newton's work. This was the purely mathematical elaboration of the various infinitesimal methods of the French and English mathematicians, by which they were all brought together, simplified, and united into a calculus with strict rules, a practical notation, and an easy algorithm. Newton himself had for the purposes of his great work invented a new and powerful

[1] A collection of Leibniz's writings on this subject will be found in the 7th volume of M Foucher de Careil's edition of Leibniz's Works, Paris, 1875. Of the projects of Leibniz, only the Academy of Berlin came into existence during his lifetime (1700 and 1701); the others were discussed at great length with the Elector of Saxony, with the Emperor, and with Peter the Great. The Academy of St Petersburg was founded in 1724, eight years after the death of Leibniz. The Academy of Vienna did not come into life till 1846, and in the same year that of Saxony was founded, which has its seat at Leipsic. Leibniz had the largest views on academic life and work: they were to embrace the historical and philosophical studies as well as the purely scientific, and were to stand in relation with the higher and lower educational institutions. His ideas are best realised at Berlin. See Jacob Grimm's interesting discourse, entitled 'Ueber Schule Universitat Akademie' (Kleine Schriften, vol. i. p. 211, &c.)

instrument, afterwards called "the method of fluxions"; but he had not made it generally known before the invention of Leibniz was published.[1] This, though much later in time, had been perfected and applied by his friends and followers in a most extensive manner, and had, in fact, become the recognised mathematical language of the Continent. No learned body did more than the Paris Academicians to perfect (with purely scientific

[1] Leibniz seems to have been in possession of his method as early as 1675, and communicated it to Collins in 1677. It was, however, not published before 1684 in the 'Acta Eruditorum,' and then probably only on account of some writings of Tschirnhausen trenching on the same subject. Newton seems to have been in possession of his methods as early as 1665, fully ten years before Leibniz made use of his. Immediately after the publication of Leibniz's paper in 1684, the differential calculus was taken up by the Continental mathematicians, especially by James Bernoulli (1654-1705) and John Bernoulli (1667-1748), and the Marquis de l'Hopital, who published the first treatise on the new calculus in 1696. Newton did not publish any account of his method, though he must have used it extensively in arriving at the results contained in the 'Principia.' Different views have been expressed on the reasons which induced Newton to withhold from publication his new methods, and the question to what extent Leibniz owed the first suggestions of his method to Newton remains also undecided. Those who take an interest in the personal question should refer to the original documents, the 'Commercium Epistolicum,' published by the Royal Society in 1715; the pamphlet of Gerhardt, 'Die Erfindung der Differentialrechnung' (Halle, 1848). An extreme view, unfavourable to Leibniz's originality, is taken by Sloman, 'Leibnitzens Anspruch auf die Erfindung der Differentialrechnung' (Leipzig, 1857); but it has not been generally adopted by those who have examined into the subject. As to the superiority of the Continental notation for practical purposes, this seems to have been generally admitted at the beginning of this century, when it was introduced into English mathematical works. In the school of W. R Hamilton of Dublin the notation used by Newton acquired a peculiar importance, and it is still occasionally used in some important works like Tait and Steele's 'Dynamics of a Particle,' and Thomson and Tait's 'Natural Philosophy.' See on this Tait's article on Hamilton in the 'North British Review' (Sept 1866). The importance of the labours of the Continental school, headed by Leibniz, for the diffusion of the new methods, is well described by Remont de Montmort in a letter to Brook Taylor, dated 18th December 1718, and given in the appendix to Brewster's 'Life of Newton' (vol. ii. p. 511, &c.) Those who take more interest in the fate of ideas and the progress of thought than in personal matters will do well to read this letter.

interest) this new calculus, which in the course of the eighteenth century had in the hands of Lagrange been adapted to all the purposes and problems contained or suggested in Newton's 'Principia.'

12. Modern analytical methods.

This leads me to a third and yet more important element of scientific thought, which was peculiar to the Continental, and especially to the French mathematicians, counting among them Leibniz, who, though a German, was wholly trained in the French school. This factor is the establishment of pure mathematics on an independent foundation, and the cultivation of research into the abstract relations of quantity, without reference either to geometrical or mechanical problems and applications. It is the modern analytical spirit introduced by the great French algebraists of the seventeenth century, which looks upon geometry, mechanics, and astronomy merely as "questions d'analyse," and makes their solutions depend upon the perfecting of an abstract calculus rather than on the study of these individual problems themselves. Opposed to this spirit of analysis, which in general seeks the solution of any given question by looking upon it as a special case of a wider and more abstract problem, is the method known to the ancients, which never loses sight of the actual application, be it a figure in geometry or a special arrangement of physical forces, and is more interested in the peculiarities of the individual case than in the abstract formula of which it may be considered an application. This opposite view regards the calculus and mathematics in general merely as an instrument, the value of which lies solely in its application to real physical problems. It is usually

termed the synthetical method, and has in modern times survived principally in England, where inductive reasoning, based upon observation of detail, has since the age of Lord Bacon been most successfully cultivated.[1] These different ways of approaching the same subject will frequently engage my attention in the course of this survey: the greatest mathematicians of modern times have recognised the importance of both aspects, and the enormous progress of the science itself has depended, no doubt, on an alternating employment of them. Leibniz clearly foresaw this when, in his correspondence with Huygens and others, he urged the necessity of not abandoning the purely geometrical view, or entirely sacrificing the older for the modern methods.[2] There can, however, be no doubt that

13. Older synthetical method.

[1] See on this point the opinion of an authority, Hermann Hankel, in his highly interesting and suggestive lecture, 'Die Entwickelung der Mathematik in den letzten Jahrhunderten' (Tubingen, 1869, republished by P. du Bois-Reymond, 1884). Speaking of the age of Leibniz he says: "Though on the Continent mathematicians were not so conservative as in England, where a purely geometrical exposition was considered to be the only one worthy of mathematics, yet the whole spirit of that age was directed to the solution of problems in geometrical clothing, and the result of the calculus had mostly to be retranslated into geometrical forms. It is the inestimable merit of the great mathematician of Basel, Leonhard Euler, to have freed the analytical calculus from all geometrical fetters, and thus to have established analysis as an independent science. Analysis places at its entrance the conception of a function, in order to express the mutual dependence of two variable quantities. . . . The abstract theory of functions is the higher analysis. . . . The conception of a function has been slowly and hesitatingly evolved out of special and subordinate conceptions. It was Euler who first established it, making it the foundation of the entire analysis, and hereby he inaugurated a new period in mathematics" (p. 12, &c.)

[2] To Huygens, 16th September 1679: "Je ne suis pas encor content de l'Algèbre, en ce qu'elle ne donne ny les plus courtes voyes, ny les plus belles constructions de Géométrie. . . . Je croy qu'il nous faut encor une autre analyse proprement géométrique ou linéaire, qui nous exprime directement *situm*, comme l'Algèbre exprime *magnitudinem*. Et je croy d'en avoir le moyen, et qu'on pourroit représenter des figures et mesures des machines et mouvements en caractères, comme l'Algèbre représente les nombres ou grandeurs" (Leibniz, Mathem. Werke, ed Gerhardt, vol. ii. p. 19).

the great success which attended Laplace's work, the elaboration of a system of the universe out of the principles of Newton, was largely due to the perfection which the analytical methods had gained in the hands of his predecessors, and to the skill with which he himself reduced the several problems to purely analytical questions.

But however much exact methods, learned societies, and regal endowments may do to promote the growth of the scientific spirit, experience has shown that popular favour and interest furnish a still more effective stimulus. Even the most abstract reasonings of the mathematician require to be brought into some connection with the general concerns of mankind, before they can attract talent from outside, or enter into that healthy action and reaction which are the soul of all mental progress. In this respect, also, France during the second half of the eighteenth century was far in advance of other countries. No other literature of that age can be compared with that of France, when we look at the influence or the expression which modern scientific views and interests had already attained in it; and no other country could at the end of the eighteenth century boast of such splendid means of scientific instruction as then existed in Paris. In two important departments—the popularisation and the teaching of science—France for a long period led the way.[1] A general inter-

14 Influence of science on French literature.

To Bodenhausen (about 1690): "I am of opinion that in the problems of ordinary Geometry the *methodus Veterum* has certain advantages over *Analysin Algebraicam*, and I think I have remarked to you that there remains an *Analysis geometrica propria, toto cœlo ab Algebra diversa et in multis longe Algebra compendiosior utiliorque*" (ibid., vol. VII. p. 359). "It is certain that algebra, by reducing everything *a situ ad solam magnitudinem*, hereby very frequently complicates things very much" (p. 362)

[1] Perhaps it would be more correct to say that science was fashionable than that it was popular in the

est was thus created in the proceedings and debates of the Academy, and the discoveries of its illustrious members found their way into the lectures and text-books of the professors. Whatever eminence German science may have gained in this century, from a purely literary point of view, through the works of A. von Humboldt, or English science through those of Darwin, the history of both literatures during the eighteenth century can be written almost without any reference to science at all—so small was the direct influence of such giants as Newton and Leibniz on the popular mind. But who could exclude from a history of the elegant literature of France the names of Voltaire, of Buffon, of D'Alembert, or of Condorcet? These form a connecting link between science and general literature.[1] A study either of English or

eighteenth century in France. But it became popular through the influence of the great schools of Paris. Before becoming popular with the masses it became so in cultivated and literary circles. The result has been that science in France alone has attained to a perfect form of expression. Whereas in other countries the great models of original research and thought were written in the severe style handed down by the ancients (Newton's 'Principia' and Gauss's 'Disquisitiones Arithmeticæ'), the great work of Lagrange (the 'Mécanique analytique') is a model of literary style in the modern sense. Science in our age has become popular through its applications. It is the utilitarian spirit that has popularised science in Germany and England. In France alone science, before coming under the influence of the utilitarian, came under that of the literary spirit It was the influence of the academies that brought this about. See Maury, 'Les Académies d'autrefois,' vol. i p. 178, &c. More than with Richelieu, the interest in science nowadays is unfortunately only too often purely "metallic" (quoted from Lord Chesterfield's Letters). See also on the literary as compared with the modern practical character of science, Maury, ibid., p. 161.

[1] "On érigeait même en principe la nécessité pour un philosophe de ne rester étranger à aucune science. 'L'esprit philosophique fait tant de progrès en France depuis quarante ans,' écrivait Voltaire à madame Du Châtelet, en lui dédiant sa tragédie d'Alzire, 'que si Boileau vivait encore, lui qui osait se moquer d'une femme de condition, parce qu'elle voyait en secret Roberval et Sauveur, il serait obligé de respecter et d'imiter celles qui profitent publiquement des lumières des Maupertuis, des Réaumur, des

15 Absence of this influence in England and Germany

of German eighteenth-century literature does not introduce one to the great controversies of science, but a study of Voltaire leads one into the midst of the profound problems of the Newtonian and Cartesian philosophy, the disputes on the correct measure of force.[1] Buffon's influence, also, by spreading a taste for the study of nature and by making objects of natural history attractive, was probably much more important than his actual contributions to the natural sciences themselves.[2]

16. Schools of science in Paris.

For the growth and diffusion of the scientific spirit itself, the great schools in Paris were even of greater value than the popular writings of Voltaire and Buffon. Most of the Academicians were trained in these schools,

Mairan, des Du Fay et des Clairault; de tous ces véritables savants qui n'ont pour objet qu'une science utile, et qui, en la rendant agréable, la rendent insensiblement nécessaire à notre nation. Nous sommes au temps, j'ose le dire, où il faut qu'un poete soit philosophe et où une femme peut l'etre hardiment.' En parlant ainsi, Voltaire ne faisait qu'exprimer l'opinion de son siècle, et ambitieux lui-même de réunir le titre de géomètre à celui de poete et d'historien, il s'était fait expliquer par madame Du Châtelet la physique de Newton" (Maury, 'Les Acad. d'autrefois,' vol. i. p. 156).

[1] See Maury, vol. i p. 157, &c.; and Du Bois-Reymond, "Voltaire als Naturforscher" in 'Gesammelte Reden,' vol. i. p. 1.

[2] "Sans l'éloquence de Buffon, la zoologie serait demeurée encore longtemps le privilége d'un petit nombre; elle eut laissé indifférents ceûx que la nature émeut moins que le charme de la parole. La vieille éducation classique avait le tort de nous laisser très-ignorants des choses du monde créé. Buffon communiqua aux sciences le charme des lettres. La curiosité s'éveilla, et en 1760, Valmont de Bomare put ouvrir à Paris le premier cours d'histoire naturelle; il fut assidûment suivi" (Maury, vol. i. p. 283). A. von Humboldt had a similar influence in Berlin seventy years later. See Du Bois-Reymond, *loc. cit.*, vol. i. p. 510. Guardia, 'Histoire de la Médecine' (Paris, 1884), says of Buffon, "Fontenelle avait rendu la science aimable et accessible. Buffon l'associa à la philosophie et aux lettres et l'introduisit définitivement dans la société" (p. 384). What a contrast, when we read in the 'Life of Sir W. R. Hamilton' (by R. P. Graves, vol. ii. p. 196) that Dr Buckland's communication at the Bristol meeting of the British Association (1836) "was apparently the first occasion of bringing before the public mind in England the geological doctrine of the great antiquity of the earth; for out of the expressly scientific circles, very little—you [viz., Count Adare] are aware—is known of what scientific men are about"!

and many of them taught there for many years[1] It was with a true insight into the higher intellectual needs of the nation that the successive Governments of the Revo-

[1] Before the age of the Revolution, which did so much to promote higher scientific education, Paris possessed already many great schools. First in importance was the Collège de France, founded in 1530 by Francis I. Gassendi and Roberval taught there in the seventeenth century, and about the middle of the eighteenth century science began to be more extensively represented, Lalande and Daubenton occupying chairs. The Collège et École de Chirurgie was an ancient establishment. There was the Jardin des Plantes, with Buffon, Lemonnier, Daubenton, and Fourcroy; the École royale des Mines, founded in 1783, where Duhamel taught metallurgy; the École des Ponts et Chaussées, founded by Turgot in 1775 Daubenton, Fourcroy, and Vicq d'Azyr taught in the École vétérinaire d'Alfort, founded in 1766. Besides the Académie des Sciences, the Académie royale de Chirurgie, founded by Lapeyronie under Louis XV. in 1731, had a great influence on the development of anatomy and surgery during the eighteenth century. Tenon and Petit, as well as Quesnay the economist, were amongst its members, and it kept up a lively intercourse with anatomists all over Europe. The Paris academies had also their representatives and connections in the provinces. Independent academies of science were affiliated with the Académie des Sciences—1716 at Bordeaux, 1706 at Montpellier, 1746 at Toulouse, 1766 at Béziers. Before having received their *lettres patentes*, which gave their members certain privileges, most of these academies had existed as independent societies. Other provincial academies, such as Arles (1668), Nîmes (1684), Soissons (1674), Marseilles (1726), were affiliated with the Académie française. Others, such as Caen (1705), Lyons (1724), Dijon (1740), Rouen (1744), Amiens and Nancy (1750), Besançon (1757), Metz (1760), Clermont (1780), Orléans (1786), were not specially affiliated. These dates show how very much earlier a literary and scientific organisation existed in France than in other countries. The Protestant universities in Germany formed an organisation of a different kind, with which I shall deal later on. The academic system, so early developed in France, was of great use to the culture of the sciences. French science is usually considered to be almost entirely located in Paris. M. Bouillier ('L'Institut et les Académies de Province,' Paris, 1879) has drawn attention to the great services of this network of academies. Many of the most eminent writers belonged to these provincial centres, and worked for them even after becoming members of the more celebrated academies. Montesquieu is connected with Bordeaux, Cassini and many eminent doctors with Montpellier, Dijon has the honour of bringing out Rousseau, and Toulouse gave prizes to Bossut and Clairault. Robespierre's name is connected with the Academy of Arras, Marat discourses at Rouen and Lyons on electricity and optics, and Danton and Bonaparte compete for the *prix Raynal* at Lyons. "Mais," says M. Bouillier, "ce qui nous semble le plus digne de remarque et d'éloge, ce sont les écoles gratuites de dessin, les cours gratuits de physique, de chimie,

lution, in the midst of the more pressing problems of national safety and welfare, betook themselves to the solution of the great problem of national education and the instruction of all grades of society. "The Convention," says the historian of public instruction,[1] "affords us the strange and grand spectacle of an assembly, which on the one side seems to have no other mission than to crush in the name of public welfare everything that stands in the way of the triumph of the Republican State, and which can see no other way of attaining this than the most terrible and cruel of tyrannies; and which on the other side devotes itself, with a stoical calm and serenity, forming a surprising contrast to its acts, to the study, the examination, and the discussion of all the problems involved in public instruction, of all the measures conducive to the progress of science. It had the glory of creating institutions, some of which were carried away by the blast of the Revolution, but among which the most important still exist for the great honour of France, and bear proof of the loftiness of her ideas."[2]

17. Promoted by Governments of Revolution.

d'histoire naturelle, d'anatomie, d'antiquités, fondés par un certain nombre d'académies et, entre autres, par Dijon, par Rouen, par Bordeaux, par Toulouse, par Montpellier, et dont les professeurs étaient des membres, non rétribués de ces académies. . . . A combien de jeunes talents les académies provinciales n'ont-elles pas donné l'essor, par leurs récompenses solennelles et leurs encouragements? Combien de leurs lauréats ne sont pas devenus des hommes célèbres?" (p. 81, &c.) Besides Bouillier, consult on these matters the several articles, "Académie," "Collége," "École," in the 'Grande Encyclopédie.'

[1] C. Hippeau, 'L'Instruction publique en France pendant la Révolution,' 1e série, préface, p. xix.

[2] It appears nowadays a kind of paradox that, as M. Hippeau remarks, in the very year 1793, when "the Convention was labouring with a feverish ardour at the creation of schools of all degrees," this same Convention, on a report of the Committee of Public Instruction, voted on the 8th of August the suppression of all the academies of Paris and the provinces. On this M. Bouillier ('L'Institut et les Académies,' p. 95) remarks: "Bientôt il est vrai, les académies devaient renaître après la chute de la

It was of immense importance to the cause of science that in many of the discussions of that assembly a marked preference was shown for the scientific side of instruction. In this matter, as in many others, the successful constructive efforts of the Revolutionary Governments came from the side of those brought up in the

Montagne et du Comité de salut public. Nous n'ignorons pas que c'est encore la Convention qui, prise d'un tardif remords, la veille seulement du jour où elle devait faire place à un autre gouvernement moins despotique et moins cruel, décréta l'organisation de l'Institut. Mais la Convention du 3 brumaire an iv. n'était plus celle de 1793 ; c'était en réalité une autre Convention, épurée, décimée, renouvelée, animée d'un tout autre esprit," &c., &c The idea of a national Institute for the advancement of letters, science. and arts was a very early one (see 'Rapport de Talleyrand Périgord,' September 1791, Hippeau, p 102) The explanation how the same Government which was labouring at the problem of a national instruction, crowned by the higher teaching and research of an Institute, could begin by closing the existing academies and universities, lies in this, that the aim was to make education general and learning popular, not merely fashionable, as it had been. See, for instance, what Ducos said on the 18th December 1792. "Les mœurs d'un peuple corrompu ne se régénèrent point par de légers adoucissements, mais par de vigoureuses et brusques institutions. Il faut opter ouvertement entre l'éducation domestique et la liberté ; car citoyens, tant que par une instruction commune vous n'aurez pas rapproché le pauvre du riche, le faible du puissant ; tant que, pour me servir des expressions de Plutarque, vous n'aurez pas acheminé à une même trace, et moulé sur une même forme de vertu tous les enfants de la patrie, c'est en vain que vos lois proclameront la sainte égalité, la République sera toujours divisée en deux classes : les *citoyens* et les *messieurs*" (Hippeau, 2e série, p. 21) It was because the academies and colleges supported "les messieurs" that they were suppressed In the end education must always begin from above, and before the people can be taught you must form their teachers. See Lakanal's Report on the Écoles normales, Hippeau, vol. i p. 408. The academies and colleges of the eighteenth century were closed in order to make room for that uniform system of public instruction described by Talleyrand and Condorcet, but not without a frequently expressed admiration for the work which they had done See the defence of the academies by Condorcet (Hippeau, *loc. cit.*, vol. i. p 272), and the tribute to the "Collége de France," by Gilbert Romme (ibid., vol i. p. 308). The arguments for radical change are summed up by that speaker as follows : "L'existence de ces corps privilégiés blesse tous nos principes républicains, attaque l'égalité et la liberté de penser et nuit aux progrès des arts Mais si leur organisation est vicieuse, les éléments en sont bons, et nous serviront utilement dans l'organisation nouvelle de l'instruction publique que vous allez décréter" (p. 309)

school of Voltaire and the Encyclopædists, whilst the work of destruction had been performed by the followers of Rousseau. No one has expressed himself on the value of scientific study and knowledge in a clearer or more far-seeing manner than Condorcet. In his 'Report and Project of a Decree on the General Organisation of Public Instruction,' which he presented to the National Assembly in the name of the Committee of Public Instruction, he says:[1] "Many motives have brought about the kind of preference which is accorded to the mathematical and physical sciences. Firstly, for men who do not devote themselves to long meditations, who do not fathom any kind of knowledge—even the elementary study of these sciences is the surest means of developing their intellectual faculties, of teaching them to reason rightly and to analyse their ideas.[2] . . . It is because in the natural sciences the ideas are more simple, more rigorously circumscribed, it is because their language is more perfect, &c., &c. . . . These sciences offer a remedy for prejudice, for smallness of mind—a remedy, if not more certain, at least more universal, than philosophy itself.[3] . . . Those

18. Condorcet

[1] It was presented on the 20th and 21st April 1792. See Hippeau, 1e série, pp. 185-288. It was printed by order of the Convention, Paris, Imprimerie nationale, 1793.

[2] Ibid., p. 203.

[3] Ibid., p. 204. It is interesting to see how in all these reports the exact sciences are placed in the foreground. See, for instance, what Gilbert Romme says of the teaching of the proposed *instituts* "Les sciences mathématiques et physiques, morales et politiques, l'agriculture et les arts mécaniques, la littérature et les beaux-arts, composeront l'enseignement des instituts où l'on pourra suivre, dans leurs éléments, l'échelle entière des connaissances humaines" (vol. i. p. 322). "Les lycées seront l'école des gens instruits; ils embrasseront les sciences, les arts et les lettres dans toute leur étendue." One is forcibly reminded that the most perfect realisation of this arrangement of studies is to be found a century later in the provincial science colleges of this country. The preference, however, is now given to science mainly for ultilitarian reasons: the difference is shown by

who follow their course, see the coming of an epoch when the practical usefulness of their application will reach greater dimensions than were ever hoped for, when the progress of the physical sciences must produce a fortunate revolution in the arts. And lastly, we have yielded to the general tendency of men's minds, which in Europe seem to incline towards these sciences with an ever-increasing ardour. . . . Literature has its limits, the sciences of observation and calculation have none. Below a certain degree of talent, the taste for literary occupations produces either ridiculous pride or a mean jealousy towards such talents as one cannot attain. In the sciences, on the contrary, it is not with the opinion of men but with nature that we have to engage in a contest, the triumph of which is nearly always certain, where every victory predicts a new one."[1]

19 Lakanal

"It is," says Lakanal, in his report on the "Écoles centrales," 16th December 1794, "of great importance for the nation to assure itself that the mathematical sciences are cultivated and deepened, for they give the habit of accuracy: without them astronomy and navigation have no guide; architecture, both civil and naval, has no rule, the sciences of artillery and of fortification have no foundation"[2] Gradually, under the pressure of exter-

the importance then attached to mathematics as a training of the intellect in precise thinking, nowadays it is the mechanical side that is favoured, and this is only too often destructive of the truly scientific and exact spirit

[1] Hippeau, *loc cit*, p 258. Cf. p. 261: "Hâtons-nous . de porter dans les sciences morales la philosophie et la méthode des sciences physiques" (Condorcet)

[2] Hippeau, vol i. p 432 It is interesting to see how the study and teaching of the sciences in course of the second half of the last century in France undergo a development. The literary interest predominates in Fontenelle Buffon and Voltaire add to it the philosophical and

nal events, the exigencies of war and the defence of the country gain the upper hand, and a central establishment is founded to cultivate and teach the sciences and arts, "upon which depend the defence of the Republic by land and sea."[1] Few of the higher and philanthropic aims of the great educational leaders of the early years of the Revolution—of Mirabeau, of Talleyrand, of Condorcet—were realised, little was done for primary education; but science can boast of having been worthily represented and supported in the two great schools which still bear their original designation, and which can show a record of celebrated names and magnificent work superior probably to that of any other similar institution in Europe.

20. École normale École polytechnique.

They are the "École normale supérieure" and the "École centrale des Travaux publics," better known by the title "École polytechnique."[2] The founders of this

philanthropic, the Encyclopædists and Condorcet the educational, the events of the Revolution and the discussions in the Assemblies bring out more and more the instructive, the utilitarian, and the economical aspects. The only creations which resulted were those in which the latter aims were predominant.

[1] Lakanal, see Hippeau, vol. i. p. 447.

[2] To these two great schools must be added as a third the "Muséum d'Histoire naturelle," "le plus magnifique établissement que les sciences aient possédé" (Cuvier, "Éloge de Fourcroy," part ii of the 'Éloges historiques,' p. 44, Strasbourg, 1819). The foundation of the "École centrale des Travaux publics" was proposed by Barère on the 11th March 1794, and definitely organised on the report of Fourcroy (Hippeau, vol. i. p. 446) by a decree of 7th vendémiaire, an iv. (name changed to École polytechnique, 15th fructidor). The opening of the courses was announced for the 10th frimaire following (Hippeau, vol. ii. pp. 139, 174, 175). The foundation of the "Écoles normales" was proposed by Barère (13th prairial, an ii.), and decreed on a report of Lakanal (Hippeau, vol. i. p. 423) on the 9th brumaire, an iii. (30th October 1794) (ibid., vol. ii. p. 179). The courses opened on the 1st pluviose. The work of the school was distributed as follows: Mathematics, Lagrange and Laplace; physics, Hauy; descriptive geometry, Monge; natural history, Daubenton; chemistry, Berthollet; agriculture, Thouin; geography, Buache and Mentelle; history, Volney; morals, Bernardin de St Pierre. (Hippeau, vol. ii. p. 180, where also will be found extracts from the 'Moniteur' of the 9th pluviose on the opening addresses.) The oldest pupil was Bougainville, the great

magnificent institution recognised "that, in spite of the diversity of applications, mathematics and physics are the indispensable basis of the studies in view."[1] Though the first period of the life of the École normale only counted four months,[2] we are indebted to it for the

traveller The École polytechnique received an allocation of £12,000, and had 400 pupils to start with On the 20th frimaire, an iii, the Convention, on a report of Thibaudeau, voted the necessary expenses for the enlargement of the Muséum d'Histoire naturelle (Hippeau, vol ii. p. 196),—*viz.*, nearly £8000 for expenses, and £200 for each of the professors The Museum had been originally destined for the culture of medicinal plants. Tournefort had given a great impetus to botanical, and Buffon, with Daubenton, to zoological studies The Convention added several to the courses regularly held there on natural history, botany, mineralogy, and general chemistry. "Ces cours," says Thibaudeau, "fournissent 500 leçons par an, offrent l'ensemble le plus vaste et le plus complet d'enseignement sur toutes les branches d'histoire naturelle dont le plus grand nombre manquaient totalement à la France et dont quelques-unes manquent encore à l'Europe, l'application immédiate de toutes les sciences naturelles au commerce et aux arts"

Of other scientific and teaching institutions I must mention the "Bureau des Longitudes" This was organised by the Convention on a discourse by Grégoire, 7th messidor, an iii (24th June 1795), in which he refers to the British Board of Longitude and the superiority of the British navy (Hippeau, vol ii p 219) The appointments to this bureau were the *géometres* Lagrange and Laplace, the *astronomes* Lalande, Cassini, Méchain, Delambre, one of whom had to deliver a course of astronomy, the travellers Borda, Bougainville, the *géographe* Buache, and the artist Carocher It had charge of the observatory, which had already been reorganised by a decree promoted by Lakanal on the 31st August 1793 (Hippeau, vol. ii p 76), and published in the 'Connaissance des Temps.' There were, besides, several military schools and the medical schools, not to mention other foundations less connected with our subject but equally important, such as the School of Oriental Languages, established in the Bibliothèque nationale (germinal, an iii, Hippeau, vol ii p 215); the Écoles de Santé, established 14th frimaire, an iii, on a report of Fourcroy, in Paris, Strasbourg, and Montpellier (Hippeau, vol. ii. p 194).

[1] Ibid, vol. i p. 450

[2] The École normale was closed on the 30th floréal, an iii, on a decree of the Convention dated the 7th of that month. Danton explained that the school had not taken the line which the Convention had marked out—the courses in general having offered a direct teaching of the sciences rather than an exposition of the methods which are to be adopted in teaching (Hippeau, vol ii. p. 215) It also seems that the eminent teachers of this institution had few pupils sufficiently prepared to follow them. The École normale was reopened in the year 1808 under the Empire, by the same decree of 17th March which organised the University of France

21 Monge's 'Descriptive Geometry.'

foundation of a new branch of science—the 'Descriptive Geometry' of Monge, which was given to the world through shorthand notes[1] from his lectures delivered in that institution. They form the beginning of the new science, since developed by Poncelet, Steiner, and others, and known under the name of "projective geometry."[2]

22 Science of Chemistry

Next to mathematics with its analytical and graphical application to physics and the arts, the subject most cultivated in these higher educational establishments of Paris at the end of the last century was the new science of chemistry. With some justice this science has been termed a French science,[3] not so much because even at that time

[1] See the account of the origin of this branch of mathematics in Brisson's edition of the 'Géométrie descriptive,' Paris, 1847. In the programme prefixed to the treatise the three aspects of the new school—the national, the practical, and the educational—are well set forth: "Pour tirer la nation française de la dépendance où elle a été jusqu'à présent de l'industrie étrangère, il faut premièrement diriger l'éducation nationale vers la connaissance des objets qui exigent de l'exactitude . Il faut, en second lieu, rendre populaire la connaissance d'un grand nombre de phénomènes naturels. . . La géométrie descriptive est un moyen de rechercher la vérité; elle offre des exemples perpétuels du passage du connu à l'inconnu; et parcequ'elle est toujours appliquée à des objets susceptibles de la plus grande évidence, il est nécessaire de la faire entrer dans le plan d'une éducation nationale." Monge generalised and placed on a scientific basis the methods used previously by carpenters and stonecutters, and partially dealt with geometrically by Courcier, Derand, Mathurin, Jousse, and Frezier. See Montucla, 'Histoire des Mathématiques,' vol. iii. p. 15.

[2] Monge taught also at the École polytechnique from the beginning. See the remarks of Chasles ('Rapport sur les Progrès de la Géométrie,' Paris, 1870, p. 2): "L'enseignement théorique et profond qui a été la base de la première et judicieuse organisation de ce grand établissement était éminemment favorable aux progrès de la science, en même temps qu'il préparait sérieusement les élèves à l'entrée dans les écoles d'application." The author then refers with regret to the less scientific tone which had crept into the studies of that great school in the course of this century. See also p. 379.

[3] A. Wurtz ('Histoire des Doctrines chimiques,' Paris, 1868, p. 1): "La chimie est une science française; elle fut constituée par Lavoisier." Cf. Dumas ('Leçons sur la Philosophie chimique,' Paris, 1837, p. 137). Buckle ('History of Civilisation,' &c., 3 vols., vol. ii. p. 366, London, 1866) says: "That we owe to France the existence of chemistry as a science will be admitted by every one who uses the word science in the sense

chemistry was not indebted to illustrious foreigners[1] for some of its most important discoveries, as because the modern scientific spirit of accurate measurement first took hold of chemical phenomena on a large scale in the many important investigations which bear the name of Lavoisier and his followers, through whom the great reform of modern chemical knowledge and research was permanently established. It has been significantly pointed out[2] that it was the union of mathematical with empirical knowledge which, through men like Laplace, Meusnier, Monge, first

in which alone it ought to be understood, &c. . . . Until Lavoisier entered the field there were no generalisations wide enough to entitle chemistry to be called a science" The correctness of this view is fully and impartially examined by Hermann Kopp ('Die Entwickelung der Chemie in der neueren Zeit,' Munchen, 1873, p 89, &c) He fully upholds the claims of Lavoisier to be called the father of modern chemistry (p. 145). See also what Liebig says.

[1] These were mainly, Black (discovered carbonic acid, called fixed air, in 1754), Cavendish (discovered hydrogen or inflammable air in 1767), and Priestley, who between 1771 and 1774 discovered oxygen (dephlogisticated air), nitrogen (phlogisticated air), and several of its compounds, among them ammonia (alkaline air) Of Priestley it is said by Cuvier that he may well be considered as one of the fathers of modern chemistry, "mais c'est un père qui ne voulut jamais reconnaître sa fille" ('Éloges,' vol i p. 208). Elsewhere ('Rapport historique sur les Progrès des Sciences naturelles,' Paris, 1810, p 90) Cuvier dates the revolution in chemistry from the introduction of the mathematical spirit: "Il en est une cause encore plus essentielle à laquelle même on doit à proprement parler, et cette théorie nouvelle, et les découvertes qui l'ont fait naître. . . . C'est l'esprit mathématique qui s'est introduit dans la science et la rigoureuse précision qu'on a portée dans l'examen de toutes ses opérations. . . . C'est dans le Traité élémentaire de Lavoisier que l'Europe vit pour la première fois avec étonnement le système entier de la nouvelle chimie," &c.

[2] Kopp, *loc. cit.*, p. 202: "Indeed, if we look at those who first worked together with Lavoisier or in his spirit, we shall find such as had devoted themselves principally to mathematics or mathematical physics, men like Laplace, Meusnier, Monge. Among chemists Lavoisier stood for a long time almost alone in his opinions." This view is also taken by Cuvier ('Rapport,' p. 91): "Les nouveaux chimistes français . . . ont eu à se louer du concours de quelques-uns de nos géomètres les plus distingués," &c , and he attributes the next great step in chemical science to a similar introduction of a "rigueur toute mathématique" ('Rapport sur la Chimie lu à la Séance des 4 Acad ,' 23rd April 1826).

brought about the general recognition of Lavoisier's ideas; whereas the more exclusive representatives of chemistry, such as Berthollet and Guyton, held aloof for some considerable time. In the earlier syllabus of the École polytechnique, chemistry was brought into a similar proximity with the mathematical branches. And Berthollet's 'Statique chimique' denotes by its title alone the mathematical spirit in which the work was conceived.

23. New mathematical sciences.

About that time also two new sciences were, if not invented, at least set on a firm basis, by which the use of mathematics was very largely extended, and by which great realms of interesting facts were made accessible to accurate measurements and exact reasoning. Both these sciences can be claimed by France as almost exclusively her own creations. They are the science of crystallography and the great theory of probabilities. The former was the work of the Abbé Hauy; the latter formed, next to the mechanics of the heavens, the main original contribution by which Laplace has perpetuated his name in the history of science. The theory of the Abbé Haüy, who first taught how crystals are built up from small particles of definite and regular geometrical forms, such as cubes, pyramids, &c., came to the aid of the mineralogists, who before him had vainly groped in the dark, searching for some method by which order and system could be introduced into the lifeless forms of nature as by the methods of Linnæus and Jussieu it had been introduced into the world of plants and animals. Before Haüy, the doctrines of mineralogy had been either attached to geology—especially in the celebrated school of Werner, or latterly, after the great developments in chemistry had

24. Crystallography.

set in, to chemistry—especially by Bergmann.[1] Hauy established the science of minerals on an independent foundation by studying and systematising the forms of their crystallisation, and he brought the science of mineralogy from Sweden and Germany into France, and gave it an independent position. Thus it came to form a connecting-link between the mathematical—*i.e.*, the measuring and calculating—and the purely descriptive sciences. "Mineralogy, though it is that part of natural science which deals with the least complicated objects, is nevertheless also that which lends itself least to a rational classification. The first observers named the minerals vaguely according to their external appearances and their use. It was not until the middle of the eighteenth century that it was attempted to subject them to those methods which had done service to geology and botany: the hope existed of establishing among them genera and

[1] See an account of the work of the chemical school, to which Cronsted (the inventor of the blow-pipe), Bergmann, Kirwan, and Klaproth belonged, in Cuvier's 'Rapport' (p 163). Also his "Éloge de Hauy" ('Éloges histor,' vol iii p 143, &c) The beginnings of geometrical crystallography seem to go back to Linnæus, but his view was discouraged in France by Buffon, who disliked Linnæus's writings. Whewell, who was himself an authority on crystallography, thinks Romé de l'Isle, who was not an Academician, had only scant justice done to him by Hauy and his friends ('Hist of the Induct. Sciences,' 3rd ed, vol. iii. p 176). More recent writers, such as Kobell ('Geschichte der Mineralogie,' Munchen, 1864, p 73, &c.) and Nicol (article "Crystallography," 'Ency. Brit'), have done him justice The 'Grande Encyclopédie' thus summarises the work of Romé de l'Isle: "Il mesura mécaniquement [*viz.*, with Carangeot's goniometer] les angles et établit que ces angles ont toujours une valeur constante dans une même espèce minéralogique" That of Hauy is summarised in the two laws· "1°, Tous les éléments semblables d'un cristal sont toujours semblablement et simultanément modifiés (loi de symétrie); 2°, toute facette modifiante intercepte sur les arêtes de la figure primitive des longueurs proportionelles à des multiples simples de la longueur de ces arêtes (loi de dérivation)" (Berthelot in 'Grande Encyclop,' vol xiii p 397)

species, as among organised beings, and it was forgotten that in mineralogy the principle is absent which had given birth to the idea of species—*viz.*, that of generation. The principle of individuality, such as it is conceived in the organic world—*viz.*, the unity of action of different organs which co-operate in the preservation of the same life—can scarcely be admitted in mineralogy."[1]

The Abbé Hauy, by founding the science of minerals on their regular forms of crystallisation, made mineralogy "as precise and methodical as astronomy, in fact, we can say in one word that he was to Werner[2] and Romé de l'Isle, his predecessors, what Newton had been to Kepler and Copernicus."[3]

25. Theory of Probability

From that well-defined province of science which deals in a precise and strict manner with the simple numerical relations which seem to underlie all forms of movement in nature, be they on a stupendous or on a minute scale

[1] Cuvier, "Éloge de Hauy" in 'Éloges historiques,' vol. iii. p 155

[2] The character of Werner (1750-1815) is nowhere better painted than by Cuvier in his "Éloge de Werner" (*loc. cit.*, vol. ii p. 303, &c.) "Il commence l'époque la plus remarquable de la science de la terre, et même l'on peut dire qu'à lui seul il la remplit. . . . Il s'est formé des académies entières, qui ont pris son nom" (for instance, the Edinburgh Wernerian Society, founded by Jameson, 1808-1859), "comme si elles eussent voulu invoquer son génie et s'en faire un patron d'une espèce auparavant inconnue. Qui ne croirait, à entendre parler de succès si peu ordinaires, que ce fut quelqu'un de ces hommes ardens à propager leur doctrine, qui par des ouvrages nombreux et éloquens, ont subjugué leurs contemporains, où qui se sont procuré des partisans par l'ascendant d'une grande richesse ou d'une position élevée dans l'ordre social? Rien de tout cela. confiné dans une petite ville de Saxe, sans autorité dans son pays, il n'avait aucune influence sur la fortune de ses disciples; il n'entretenait point de liaisons avec des personnes en place · d'un naturel singulièrement timide, hésitant toujours à écrire, à peine subsiste-t-il de lui quelques feuilles d'impression. . . . C'est ainsi qu'en peu d'années la petite école de Freyberg, destinée seulement, dans le principe, à former quelques mineurs pour la Saxe, renouvela le spectacle des premières universités du moyen âge," &c., &c.

[3] Cuvier, ibid., p. 163.

—*i.e.*, from the province of mechanics and astronomy—two different roads lead into those extensive domains in which, not simplicity and regularity, but endless variety and complication, seem to be the order and the rule of Life. Even a century ago the contrast must have been striking between the 'Principia' of Newton and the 'Exposition du Système du Monde' of Laplace on the one side, and the great array of volumes of Linnæus, Buffon, Jussieu, Cuvier, and Lacépède on the other; though these after all embraced only a small portion of the living forms of nature which they attempted to classify or to describe.[1] I have pointed out how the new and especially the French methods of chemistry and crystallography conquered a large portion of intermediate ground, subjected many tangled phenomena to exact treatment, and pushed the mathematical method far into the dominion of natural history. It is that other history, not natural, but human and often unnatural, which presents the opposite extreme of the great panorama of world-life. It is significant that almost at the same time that mathematical reasoning found its way into natural history, conquering an extensive province of its vast territory, an entirely different method was invented with the aim of dealing in a still more vigorous manner with the phenomena of human life and society. This was the science of statistics, and

[1] Cuvier gives some figures as to the increase of the known species during his own lifetime Lacépède had described about 1200 or 1300 distinct species of fishes; but when Cuvier pronounced his Éloge in 1826, the Cabinet du Roi contained already more than 5000 species ('Éloges historiques,' vol. iii. p. 317). Linnæus had counted in 1778 about 8000 spécies of plants. Cuvier in 1824 estimates the number as 50,000 or more (see 'Éloges,' vol. iii. p 469, &c., where he also gives some idea of the numbers of known species in the different classes of animals).

connected with it the doctrine of averages and the mathematical theory of probabilities.[1] The same great mind

[1] The beginnings of the science and theory of probabilities are not subject to controversy, as were those of the infinitesimal calculus. Pascal and Fermat about the middle of the seventeenth century entered into a correspondence relative to a question in a game of chance, propounded by the Chevalier de Méré, a noted gambler. They agreed in their answer, but could not convince their friend, who moreover made this the occasion of denouncing the results of science and arithmetic. But this comparatively insignificant problem — so different from the great cosmical problems which led to the invention of the infinitesimal calculus about the same time — was the origin of a series of investigations and discussions in which the greatest mathematicians, such as Huygens, James and Daniel Bernoulli, De Moivre, D'Alembert, and Condorcet joined. Most of them did not escape the errors and misstatements which creep in an insidious manner into the discussion and vitiate the conclusions. In fact, the science advanced through the influence of those who depreciated it like D'Alembert, and those who exaggerated its importance like Condorcet. At length, under the hands of Laplace, who defined it as common-sense put into figures and attributed to it a high educational value, it assumed a state wellnigh approaching to that perfection which Euclid gave to geometry and Aristotle to logic. Since the publication of Laplace's celebrated 'Théorie analytique des Probabilités' (Paris, 1812) writers on the subject have found ample occupation in commenting on the theorems or recasting the proofs given in that work, which holds a similar position to that occupied in another department of mathematics by the 'Disquisitiones Arithmeticæ' of Gauss (1801). Up to the present day there exist differences of opinion as to the value of the science, the two opposite views being represented in this country by Mill ('Logic,' 5th ed., vol. ii. p. 62) and Jevons ('Principles of Science,' vol. i), the latter summing up his opinion as follows: "In spite of its immense difficulties of application, and the aspersions which have been mistakenly cast upon it, the theory of probabilities is the noblest, as it will in course of time prove perhaps the most fruitful, branch of mathematical science. It is the very guide of life, and hardly can we take a step or make a decision of any kind without correctly or incorrectly making an estimation of probability" (1st ed., p 248). A similar opinion seems to have been held by James Clerk Maxwell (see Life by Campbell and Garnett, p. 143), who called the calculus of probabilities "Mathematics for practical men."[2] In this country A. de Morgan and Todhunter, the former in a popular essay in the 'Cabinet Cyclopædia' and in a profound treatise in the 'Encyclopædia Metropolitana,' the latter in his well-known History (London and Cambridge, 1865), have done a great deal to make this subject better understood. The applications of the theory have gradually increased through numerous mortality and insurance calculations; as also in the estimations of error in astronomical and physical observations, where the well-known method of least squares (first employed by Gauss in 1795, see Gauss, Werke, vol. vii p. 242; first published by Legendre in 1806, and then proved by Laplace in his 'Théorie,'

which elaborated the principles of Newton into a system of the universe, and attacked the intricate mathematical problem which this system presented, gave to the world likewise the first complete treatise on that calculus which comes into play if we eliminate from the apparently most arbitrary region of phenomena, that of human life and history, all regard for final or efficient causes, for providential design and freewill, for human error, human malice and benevolence—in fact, all notice of that element which from another and equally important point of view forms the subject of greatest interest—the inner life of the individual. It was proposed, and it has since been carried out, to look upon human beings and human events not as things possessed of an inner world of thought and freewill, but as lifeless units, more uniform and regular than the balls thrown into the urn at an election, or the counters in a game of chance By overstepping with one bound the great field of human activity, full of so much confusion and so much interest, it was proposed to investigate what knowledge would result from a purely mathematical inspection, in which human beings figured merely as units and symbols.[1] This attempt, which has since

&c , 1812) is now extensively employed. Of this branch of mathematics Bertrand says "Les plus grands géomètres ont écrit sur le calcul des probabilités, presque tous ont commis des erreurs la cause en est, le plus souvent, au désir d'appliquer des principes à des problèmes qui par leur nature échappent à la science " In the hands of Clerk Maxwell the calculus has acquired an additional interest and importance through the distinction which he made between what he termed the "historical" and the "statistical method" of treating phenomena, and the application of the latter to the kinetic theory of gases (see Life, pp 438, 562) This subject will occupy our attention in a special chapter

[1] The beginnings of the science of statistics belong likewise to the age that produced the higher mathematics More extensive "countings" seem to have been contemporaneous with more refined calculations. Hermann Conring, professor at Helmstadt, a friend of Leibniz (see Leib-

led to such interesting results, and which has furnished almost all the knowledge upon which a judicious regulation and government of society depends, was the work of Laplace, and was produced in an age and in a nation which seemed to have set at naught all ideas of order and method in human affairs, which defied all authority and all tradition, and trusted its fate to the most radical revolution which civilised society ever witnessed.[1]

It is curious to read the criticism which the first Napoleon, that wayward child of the Revolution, passed on the author of the mechanics of the heavens and the theory of probability. Laplace, like so many other men of science, had been called by the Emperor to assist in the labours of administration, but, according to his judgment, proved himself a poor administrator, being unable

niz's 'Philosophische Schriften,' ed. Gerhardt, vol. i p 155), lectured about 1660 on subjects now comprised under the term "Statistics," and about the same time John Graunt of London published 'Natural and Political Annotations made upon the Bills of Mortality' (1666) Sir William Petty, one of the founders of the Royal Society, published in 1683 'Five Essays in Political Arithmetick' The newly discovered calculus of probabilities induced mathematicians to take an interest in the subject, and to urge the desirability of gaining data for their calculations. Many of these turned upon questions of mortality and the ravages of diseases, such as the smallpox. But though undoubtedly the fact that during the French Revolution mathematicians for the first time had a great influence in administrative and governmental matters contributed enormously to the introduction of statistical methods, the great epoch in this science is allied with the name of the Belgian Quetelet (1796-1874), of whom more later on.

[1] Cantor ('Historische Notizen uber die Wahrscheinlichkeitsrechnung,' Halle, 1874, p. 6) says: "The tendency of thought which prepared the Revolution, and which is marked by an unsparing and destructive criticism of the conditions of society in state and family, could not dispense with an instrument which, more than any other, enables one to subject to general views the most different factors of civilisation. It belonged to the favourite ideas of that age, that the calculus of probabilities should be among the most important subjects of public instruction, for it was said to be the calculus of common-sense, through which alone the influence of hope, fear, and emotion on our judgment could be destroyed, and prejudice and superstition removed from the decisions of social life."

to grasp practical issues, and always descending into infinitesimals. It is hardly to be doubted now, after the lapse of a century, that the infinitesimals of Laplace play a more important part in problems of administration and government than the ideas of Napoleon. Laplace, unlike some other great scientific thinkers, attached great value to a popular exposition of the principles of his discoveries Descartes required a Fontenelle and Newton a Voltaire to make their ideas accessible and useful to the mass of students. Laplace was his own Fontenelle and Voltaire. "Few works," says Sir John Herschel, "have been more extensively read, or more generally appreciated, than Laplace's 'Essai philosophique sur les Probabilités,' and that on the 'Système du Monde' by the same author. It is not, perhaps, too much to say that were all the literature of Europe to perish, these two essays excepted, they would suffice to convey to the latest posterity an impression of the intellectual greatness of the age which could produce them, surpassing that afforded by all the monuments antiquity has left us. Previous to the publication of the 'Essai philosophique,' few, except professed mathematicians or persons conversant with assurances and similar commercial risks, possessed any knowledge of the principles of this calculus, or troubled themselves about its conclusions, regarding them as merely curious and perhaps not altogether harmless speculations Thenceforward, however, apathy was speedily exchanged for a lively and increasing desire to know something of a system of reasoning which for the first time seemed to afford a handle for some kind of exact inquiry into matters no one had ever expected to see reduced to calculation, and bear-

ing on the most important concerns of life. Men began to hear with surprise, not unmingled with some vague hope of ultimate benefit, that not only births, deaths, and marriages, but the decisions of tribunals, the results of popular elections, the influence of punishments in checking crime, the comparative value of medical remedies and different modes of treatment of diseases, the probable limits of error in numerical results in every department of physical inquiry, the detection of causes, physical, social, and moral—nay, even the weight of evidence and the validity of logical argument—might come to be surveyed with that lynx-eyed scrutiny of a dispassionate analysis, which, if not at once leading to the discovery of positive truth, would at least secure the detection and proscription of many mischievous and besetting fallacies."

Both ways of approaching the intricate phenomena of nature and history, that of mechanics dealing with the general laws of motion and of lifeless masses, and that of statistics dealing with the arithmetical properties of large numbers of units, leave out of consideration that hidden and mysterious phenomenon to which alone is attached, if not order and method, yet certainly all that commands interest in the created world: the factor of life—the existence of individuality. The view which Laplace took of the universe or of human affairs is an attempt to see how far science and reasoning can go while disregarding the principle of individuality.[1] The

26. Laplace gained his results by disregarding the principle of individuality

[1] See Clerk Maxwell on 'Science and Freewill' (Life by Campbell and Garnett, p. 438). "Two kinds of knowledge, which we may call for convenience dynamical and statistical. The statistical method of investigating social questions has Laplace for its most scientific and Buckle for its most popular expounder. Persons are grouped according to some characteristic, and the number of persons forming

method has been most fruitful, and, far from being exhausted, promises undreamt of results in the future. It was probably more from the desire to keep his view clear and his method simple, than with any necessarily sceptical tendency, that when Laplace was questioned by Napoleon how it was that in the great volumes of the 'Mécanique céleste' the name of God did not appear, he replied, "Sire, je n'ai pas besoin de cette hypothèse."

27 Individuality the centre of interest in the sciences of life

But French science did not leave that great field of research uncultivated, which is the very playground of individual life. Its cultivation was the work of that other great representative of French science—the contemporary of Laplace—Georges Cuvier[1] Linnæus had

the group is set down under that characteristic This is the raw material from which the statist endeavours to deduce general theorems in sociology Other students of human nature proceed on a different plan They observe individual men, ascertain their history, analyse their motives, and compare their expectation of what they will do with their actual conduct This may be called the dynamical method of study as applied to man However imperfect the dynamical study of man may be in practice, it evidently is the only perfect method in principle, and its shortcomings arise from the limitation of our powers rather than from a faulty method of procedure If we betake ourselves to the statistical method, we do so confessing that we are unable to follow the details of each individual case, and expecting that the effects of widespread causes, though very different in each individual, will produce an average result on the whole nation, from a study of which we may estimate the character and propensities of an imaginary being called the Mean Man"

[1] It is not necessary here to explain the reasons which have induced me to confine myself mainly to the two great names of Laplace and Cuvier as the great representatives of the exact scientific spirit, as it first asserted its supremacy in France, and from there gradually fought its way all over Europe To me it seems that nowhere has this modern scientific spirit been represented in greater completeness and greater purity. This is so much the more remarkable, as other influences and temptations were not wanting in that age and country which might have interfered with the application of the purely scientific method The scientific spirit is in danger of being contaminated by two interests which are essentially foreign to it the one is the practical, the other the philosophical Frequently they are united; and when united their influence on the progress of science has frequently been disastrous In no department of knowledge has this

begun the work of natural history by inventing a system of classification and a technical language or nomenclature. Buffon in his brilliant and elegant portraits had cast around it the charms of poetry and romance. Jussieu had imported botany from Sweden into France, and in the garden of Trianon had given a living model of the arrangement of plants; botanising had become popular through the

union of the practical and philosophical spirit been more marked than in the medical sciences. Essentially interested as it is in the immediate application of scientific discoveries to the needs of suffering mankind, we witness in the course of the seventeenth and eighteenth centuries a one-sided alliance of the art of healing with chemistry (Sylvius, 1614-1672), with physics (Borelli, 1608-1679), and with mechanics (Pitcairn, 1652-1713), and the reaction of the animists (Stahl, 1660-1734, and Hoffmann, 1660-1742), and the vitalists (Bordeu, 1722-1776, and Barthez, 1734-1806). A large portion of the history of medicine (see Haeser, 'Geschichte der Medicin,' Jena, 1881, vol. ii., and Guardia, 'Histoire de la Médecine,' Paris, 1884) consists in the account of the opposition to premature generalisations, adopted from other sciences, or still more dangerously from metaphysics As examples of the metaphysical tendency we have the Scotch systems of Cullen and Brown, and the German "Philosophy of Nature" The reasons why philosophy has so frequently allied itself with medicine, thus preventing the purely scientific spirit from gaining admission, are twofold. "Young men," says Cuvier, "adopt these theories with enthusiasm, because they seem to abridge their studies and to give a thread in an almost inextricable labyrinth" ('Rapport,' p. 333). The other reason is that the art of healing has as much a psychological as a physical side, and a philanthropic as much as a scientific interest. In respect of this it is well to note that the age and country which gave to Europe the great models of purely scientific research in Laplace and Cuvier was rich also in great thinkers who applied themselves in a philosophical spirit to the advancement of scientific and practical medicine, to the reform of hospitals, to the care of the insane, to the education of the deaf and dumb. The whole school of the ideologues, headed by Condorcet, Cabanis, and Destutt de Tracy, was closely allied with the medical profession. But however important this side of French thought may have been, its influence on the rest of Europe at that time cannot be compared with that of the purely scientific writings belonging to mathematics and natural science. Such names as Cabanis and Bichat belong to a different current of European thought, which I purposely separate from the exact or purely scientific. And this separation is justified historically by the fact that in the Académie des Sciences for a considerable time medical science was only meagrely represented, whilst philosophy during the period of the suppression of the Académie des Sciences morales et politiques, from 1803-1832, had no academic representation at all. The great name of Bichat is not among the Academicians, and Cuvier himself

writings of Rousseau, gardening and the study of plant-life had become a royal pastime, and a favourite recreation for those oppressed with the troubles of the State or the sorrows of private life. Cuvier, while asking the reason why other portions of natural history had not shared the same attention, breaks out into the following eloquent words. "The study of animals presents diffi-

explains the exclusive attitude of the Academy to the medical profession in his Éloges of Hallé, Corvisart, and Pinel ('Éloges,' vol iii p. 339, &c.) See also Maury (p 304). 'Les sciences physiques, chimiques et naturelles avaient pris une telle extension dans les travaux de l'Académie, qu'à la fin du dix-huitième siècle, la médecine, qui n'y avait jamais été au reste bien largement représentée, fut de plus en plus reléguée à l'arrière plan; ce n'était plus que de loin en loin que les médecins, les chirurgiens de la Compagnie, . . y présentaient des observations sur des points médicaux . La médecine, qui, selon la juste observation de Cabanis, tend aux hypothèses par la nature même du sujet auquel elles applique, n'offrait point assez de constance dans ses principes et d'évidence dans ses démonstrations pour satisfaire des esprits qui se détachaient tous les jours davantage des vieilles spéculations de l'école C'est ce qui explique le peu de faveur qu'elle rencontrait à l'Académie" To what extent this rigid demarcation, according to which "observations relatives aux dispositions morales et intellectuelles des individus n'entrent assurément dans les attributions d'aucune académie des sciences' ('Mémoires de l'Institut,' vol ix p 110), was beneficial to medical science is an important question In the organisation of the Institute of the 3rd brumaire, an iv (25th October 1795), there are awarded out of 60 members only 6 to medicine and surgery combined, and in the "nouvelle organisation" of 3rd pluviose, an xi (23rd January 1803), there are 6 members out of 63. This section is given as the last, even after "économie rurale et art vétérinaire" (see Aucoc, 'L'Institut,' p 3, &c.) It is interesting to note how in contrast to this the medical profession occupied for a long period a foremost place in the Royal Society of London, so much so that frequently opposition was made to the admission of new members belonging to it (see Weld, 'History of the Royal Society,' vol. i chap 4, vol ii p 153) Of 5336 papers contained in the 'Philosophical Transactions' from 1665 to 1848, 1020, the largest number in any department, belonged to anatomy, physiology, and medicine (ibid, vol ii p 565) Babbage complained of the influence of the Colleges of Physicians and Surgeons in the Royal Society, as occasionally filling the pages of the 'Transactions' with medical papers of very moderate merit; and also because the preponderance of the medical interest introduces into the Society some of the jealousies of that profession ('Decline of Science in England,' 1830, p 188) In the foundation of the British Association this union with the medical interest was dropped; though the older "Versammlung deutscher Naturforscher und Ärzte," after which it was modelled, established and maintained that union

culties which only great zeal can surmount; we have to subject them to torments in order to appreciate their physical powers, their innermost energies only reveal themselves to the dissecting-knife—only by living among corpses can we discover them. Among them we find the same spectacle as in the world, whatever moralists may say: they are hardly less wicked or less unhappy than we are; the arrogance of the strong, the meanness of the weak, vile rapacity, short pleasures bought by great efforts—death brought on by long suffering—that is the rule among animals as much as among men. With plants existence is not surrounded by pain—no sad image tarnishes their splendour before our eyes, nothing reminds us of our passions, our cares, our misfortunes—love is there without jealousy, beauty without vanity, force without tyranny, death without anguish—nothing resembles human nature."[1]

Into the centre of individual and organised life—the life of the animal and human creation—Cuvier carried exact research, grounding it on the science of comparative anatomy.[2] At the same time, he marked out as the principal problem, around which all investigations must turn, and upon which all classification must depend,

[1] 'Éloges historiques,' vol. i. p. 91.

[2] Cuvier, in the Introduction to 'Le Règne animal, distribué d'après son organisation, pour servir de base à l'histoire naturelle des animaux et d'introduction à l'anatomie comparée' (Paris, 1817), says that for thirty years he had devoted to comparative anatomy all his time (p. v), that the first results had appeared in 1795, his 'Leçons d'Anatomie comparée' in 1800 (p. vii), that he has made anatomy and zoology march side by side (p. vi). He compares natural history as a science with other sciences, stating that dynamics is become a science almost entirely of calculation, that chemistry is still a science altogether of experiments, that natural history will for a long time to come remain in most of its parts a science of observation (p. 5); he maintains that geometry is a study of syllogisms, natural history a study of method (p. xviii).

the phenomenon of individual life, that great vortex into which agencies, processes, and the elements of inorganic nature are continually drawn, from which they are continually ejected, preserving not the unity of substance but, among changing events, the unity of form.[1]

"It is not," he says, "in the substance that in plants and animals the identity of the species is manifested, it is in the form. There are probably not two men, two oaks, two rose-trees, which have the compound elements of their bodies in the same proportion—and even these elements change without end, they circulate rather than reside in that abstract and figured space which we call the form, in a few years probably there is not left one atom of that which constitutes our body to-day—only the form is persistent, the form alone perpetuates in multiplying itself; transmitted by the mysterious operation which we call generation to an endless series of individuals, it will attract successively to itself numberless molecules of different matter, all of them merely transient."[2]

[1] "La vie est donc un tourbillon plus ou moins rapide, plus ou moins compliqué, dont la direction est constante, et qui entraîne toujours des molécules de mêmes sortes, mais où les molécules individuelles entrent et d'où elles sortent continuellement, de manière que la forme du corps vivant lui est plus essentielle que la matière" ('Règne animal,' p 13, &c) "Il vient sans cesse des éléments du dehors en dedans il s'en échappe du dedans au dehors · toutes les parties sont dans un tourbillon continuel, qui est une condition essentielle du phénomène, et que nous ne pouvons suspendre longtemps sans l'arrêter pour jamais Les branches les plus simples de l'histoire naturelle participent déjà à cette complication et à ce mouvement perpétuel, qui rendent si difficile l'application des sciences générales" ('Rapport,' p 150, &c) "Dans les corps vivans chaque partie a sa composition propre et distincte; aucune de leurs molécules ne reste en place, toutes entrent et sortent successivement: la vie est un tourbillon continuel, dont la direction, toute compliquée qu'elle est, demeure constante, ainsi que l'espèce des molécules qui y sont entraînées, mais non les molécules individuelles elles-mêmes . . . Ainsi la forme de ces corps leur est plus essentielle que leur matière," &c. (ibid., p. 200).

[2] 'Éloges historiques,' vol iii p. 156.

Keeping this unity of form, this absorbing vortex of life, the totality of organisation, always before him, Cuvier, in surveying the whole region of animated nature,[1] fixes finally for the purposes of classification and division on that system of organs which expresses most truly the peculiarity of each of the great branches into which he divides the animal world—namely, the nervous system.[2] But rather than follow him at present into the

[1] "La partie anatomique du problème général de la vie est résolue depuis longtemps pour les animaux, au moins pour ceux d'entre eux qui nous intéressent le plus. Les voies que les substances y parcourent, sont connues; . . . il aperçoit aussi comment ces routes, si compliquées dans l'homme, se simplifient par degrés dans les animaux inférieurs, et finissent par se réduire à une spongiosité uniforme. Les recherches de M. Cuvier—dans les leçons d'anatomie comparée—ont achevé d'assigner à chaque animal sa place dans la grande échelle des complications de structure" ('Rapport,' p. 202, &c.)

[2] It is not my object here to give an account of the views of Cuvier, still less of his contributions to natural history, which—in spite of the special theories and laws which he and his followers established (see especially Flourens, 'Histoire des Travaux de Georges Cuvier,' 3me éd., 1858)—remained in his hands to the last pre-eminently a science of observation. It has been pointed out that Cuvier only gradually (probably about 1812) arrived at the final principle of division—*viz.*, the nervous system—and that he adopted it from others (notably Virey and De Blainville), that before 1812 he had successively used the organs of generation (1795), of nutrition, and of circulation as principles of classification. In his Report of 1808, in mentioning his own labours, he says. "M. Cuvier, en étudiant la physiologie des animaux vertébrés, a trouvé dans la quantité respective de leur respiration, la raison de leur quantité de mouvemens, et par conséquent de l'espèce de ces mouvemens. . . . En effet, M. Cuvier, ayant examiné les modifications qu'éprouvent dans les animaux sans vertébres les organes de la circulation, de la respiration, et des sensations, et ayant calculé les résultats nécessaires de ces modifications, en a déduit une division nouvelle où ces animaux sont rangés suivant leurs véritables rapports" ('Rapport,' p. 311, &c.) Compare also Carus, 'Geschichte der Zoologie,' Munchen, 1872, p. 602; Flourens, "Éloge de Cuvier," in his 'Éloges historiques,' 3me série, Paris, 1862, p. 122, &c.; Hahn in the 'Grande Encyclopédie,' article "Cuvier" See also the Introduction to the 'Règne animal,' which proposes to arrange living beings according to their "organisation," by investigating their "structure," their "internal as well as external conformation." Cuvier here states that no one before had tried to arrange the classes and orders according to the "ensemble de la structure" (p. vi). He is thus led to the law of the "subordination des caractères, . . . ayant soin d'établir toujours la correspondance des formes extérieures et intérieures qui, les unes comme les

details of his natural history, his comparative anatomy, or his palæontology, of which latter sciences he is the creator, it serves our present purpose better to learn how he viewed the object of natural science in general—how he defined its task. As the first step in civilisation was the creation of a language possessing definite rules, so the first step in the growth of a science is that taken by Linnæus, who was not terrified by this enormous work, that of giving names, of framing a nomenclature.[1] "But," says Cuvier, "to name well, you must know well. These

autres, font partie intégrante de l'essence de chaque animal" (p. xiv). He opposes former artificial classifications, such as the principle that living beings can be arranged "de manière à former des êtres une seule ligne" (p. xx). "Un être organisé est un tout unique, un ensemble de parties qui réagissent les unes sur les autres pour produire un effet commun. Nulle de ses parties ne peut donc être modifiée essentiellement sans que toutes les autres ne s'en ressentent" ('Éloges,' vol. ii. p. 279).

[1] The formation of a nomenclature or a terminology is one of the most important steps in the beginning and the progress of science. Cuvier refers frequently to this. "Nos livres saints, à leur début, nous représentent le Créateur faisant passer ses ouvrages sous les yeux du premier homme, et lui ordonnant de leur imposer des noms . . . Ces noms, qu'il est prescrit à l'homme d'imposer, ne sont pas des signes incohérens appliqués au hasard à quelques objets isolés. Pour qu'ils deviennent réguliers et significatifs, ils exigent, comme il est dit, que les êtres aient passé devant le nomenclateur" ('Éloges,' vol. iii pp. 450, 452). Nowhere is terminology more important than in chemistry. "L'un des moyens qui ont le plus puissamment contribué à faciliter l'enseignement de la science en général, et à préparer l'adoption universelle de la théorie nouvelle, c'est la nomenclature créée par cette société de chimistes français. . . . Donner aux élémens des noms simples; en dériver, pour les combinaisons, des noms, qui exprimassent l'espèce et la proportion des élémens qui les constituent, c'était offrir d'avance à l'esprit le tableau abrégé des résultats de la science, c'était fournir à la mémoire le moyen de rappeler par les noms la nature même des objets. C'est ce que M. Guyton de Morveau proposa le premier dès 1781, et ce qui fut complètement exécuté par lui et par ses collègues en 1787" ('Rapport,' p 88, &c) Cf. 'Éloges,' vol. iii. pp. 194, 482, 496. Cuvier ('Éloges,' vol. iii. p. 302) mentions "cette antipathie pour les méthodes et pour une nomenclature précise à laquelle Buffon s'est laissé aller en tant d'endroits"; he speaks of Pinel "qui avait cherché d'abord à former pour les descriptions des maladies un langage précis, modelé sur celui que Linnæus avait introduit en botanique" (ibid., vol. iii. p. 386).

beings and their parts which are to be known are to be counted by the million; it is not enough to know them singly, for they are submitted to an order, to mutual relations, which must likewise be appreciated, for it is according to this order that each has its part to play, that each disappears at its time, that they reappear similarly made, always in the same proportions, and armed with the necessary forces and faculties for the maintenance of these proportions, and of the whole of this perpetual vortex. Not only is each being an organism, the whole universe is one, but many million times more complicated; and that which the anatomist does for a single animal—for the microcosm—the naturalist is to do for the macrocosm, for the universal animal, for the play of this alarming aggregation of partial organisms."[1]

It was this sustained regard for the value of detailed research and minute observation, coupled with an equal appreciation of the unity of all regions of existence, and all branches of learning, that elevated Cuvier to the height of the science of his age and his country, and made him a true exponent of the modern scientific spirit. The works of Newton and Laplace may contain more formulæ of lasting value, more instruments of permanent scientific use—they may, for all time, have traced a few lines of the enwoven cipher of the all-pervading mechanism of nature; it is, however, well to note that he only who keeps in steadfast view the life rather than the mechanism of existence, approaches the great secret of nature, and gauges rightly the value of each component

[1] Cuvier, 'Éloges historiques,' vol. iii. p. 453.

part, or the worth of each human effort[1] In this respect the nineteenth century knows no greater figure than Cuvier, not even Humboldt, great and comprehensive as was his scientific view. The advantages also of Cuvier's position as permanent Secretary of the French Academy of Sciences were exceptional, and well fitted to bring out his extraordinary talents. We can say that in him science has become fully conscious of its true methods, its usefulness, its most becoming style, its inherent dignity, its past errors, its present triumphs, the endless career which lies before it, and the limits which it cannot transgress.

29. Cuvier's training.

Educated in Germany, at the same school as Schiller and Dannecker,[2] imbued by early experience and by

[1] "C'est la continuation de ce commandement de voir et de nommer, par où s'ouvre la vie de notre espèce, c'est la voie qui devait nous conduire soit à des contemplations plus hautes, soit seulement à des inventions utiles En effet l'histoire naturelle ne fait aucun pas sans que la physiologie et la philosophie générale marchent d'un pas égal, et sans que la société reçoive leur tribut commun ' ('Éloges,' vol iii. p 474)

[2] Cuvier has himself written an account of his early life and studies It is given by Flourens, 'Éloges,' vol i. pp. 167-193 He was born in 1769, of a Protestant stock, at Montbéliard, the capital of a small principality, situated in the Jura, and then belonging to Wurtemberg The autocratic Duke Charles (1737-1793) had founded a military academy in Stuttgart, his capital, where 400 youths were at his expense housed and educated according to a strict rule, but under the guidance of enlightened masters, and in a thoroughly modern spirit. The institution was a kind of opposition to the Protestant Church rule, which had very early spread a system of popular and compulsory education throughout the country. It is a chapter of history well worth reading The great problems of popular education as against higher instruction, Protestant discipline in the lower as against military discipline in the higher schools, the democratic as against the aristocratic spirit, the independence as against the State-regulation of University teaching, were fought out by the dukes and the Estates of Wurtemberg in a prolonged warfare, a sample of similar movements all over Germany, and well told by Perthes in his 'Politische Zustande und Personen in Deutschland zur Zeit der franzosischen Herrschaft' (Gotha, 1862, pp 501-548) Cuvier evidently saw the better side of the system, for he entered after the imperious character of the duke had been subdued by the victorious estates Forced to change his ways, which he conscientiously did, the duke laid by for his country, as a local historian says, ' a fund of in-

personal contact with that spirit of general education and universal training which then animated the German-speaking nations of the Continent, thoroughly grounded in classics and mathematics, with a cosmopolitan knowledge of languages and literature, which fitted him to understand the merits of different nations, he became the great exponent of that peculiar system of higher culture which since the time of Colbert the French had elaborated—the academic system.[1] The centre of this

telligence and acquisitions by which we have benefited up to modern times" (Perthes, p. 510). We know the other and older side of the picture from the 'Life of Schiller' (see, *inter alia*, Carlyle, 'Life of Schiller,' collected works, library edition, vol. v. p. 258). Cuvier gives a long description of the "Karlschule": "C'était un établissement vraiment magnifique. Environ quatre cents boursiers et pensionnaires, logés dans un édifice tel qu'il n'y en a aucun d'approchant en Europe (parmi ceux qui sont consacrés à l'instruction de la jeunesse), vêtus d'un bel uniforme, conduits par des officiers et des sous-officiers tirés des régiments du duc, reçevaient des leçons de tout genre de plus de quatre-vingts maîtres ou professeurs. On a beaucoup parlé de l'esprit de despotisme avec lequel le duc disposait de leurs personnes et choisissait pour chacun d'eux l'état qu'il devait embrasser, et je crois en effet qu'il en était ainsi dans l'origine de l'établissement; mais de mon temps, je n'ai rien vu de semblable, et ce qui est certain, c'est que personne ne prétendit même me donner de conseil à cet égard Il y avait cinq facultés supérieures, droit, médecine, administration, militaire et commerce" (Flourens, *loc. cit.*, p. 171).

[1] The first great representative of this academic spirit and culture was Fontenelle, who, living during a hundred years, from 1657 to 1757, was Secretary of the Académie des Sciences during forty-two years, from 1699 (the year of the reconstitution of the Academy) to 1741. Among his successors were men like Condorcet, Delambre, Cuvier, and Arago. Fontenelle gave to scientific subjects a dignified popularity, separated the departments of science and metaphysics, kept the scientific interest free from the commercial, and through his connection with the Académie française did probably more than any other writer to establish that superiority of style and diction for which the great French men of science are so remarkable and so superior to those of other countries Bertrand, himself a successor of Fontenelle, says of him. "Prêtant aux travaux de ses confrères la finesse de ses aperçus et la vivacité ingénieuse de son style, il a su dans leurs portraits, qui sont des chefs-d'œuvre, plus encore que dans l'analyse de leurs découvertes, donner aux plus humbles et aux plus modestes une célébrité imprévue et durable, et le juste et sérieux hommage qu'il rend au vrai mérite fait aimer et respecter tout à la fois les savants et la science" ('L'Académie des Sciences et les Académiciens,' p. 113). See also Voltaire's

system was the old Academy of Sciences, which, with a short interruption during the storm of the Revolution, survived,[1] and formed the principal feature in the Institute. Allied with this institution, and directly inspired by its spirit, were the great schools of natural science, the great collections of natural objects, latterly also the great medical institutions of Paris. It professed to protect scientific studies in a royal and generous manner, attracted talent from outside, rewarded foreign as well as French research,[2] and tried to keep the scientific spirit of inquiry, as well as the form in which it found expression, pure and undefiled.[3] It favoured the co-

'Siècle de Louis XIV'; Cabanis, 'Révolutions de la Médecine' (Œuvres, Paris, 1823, vol i p 200), Flourens, 'Éloges historiques,' vol. iii p 31, &c , Maury, 'Les Académies d'autrefois,' vol. i p 153, 163 *et passim*, Bouillier, 'Éloges de Fontenelle,' Introduction

[1] "Tandis que tout a été renouvelé dans la politique et les mœurs publiques . . la vie scientifique et littéraire a sensiblement gardé sa constitution . . Le Collège de France, l'Académie française, l'Académie des Inscriptions et Belles-lettres, l'Académie des Sciences, la Bibliothèque impériale, l'Observatoire, le Muséum d'Histoire naturelle, subsistent encore, comme au siècle dernier, et dans nos provinces, une foule d'académies sont d'une création antérieure à 1789" (Maury, *loc cit*, p. 1).

[2] "Euler fut quatre fois couronné pour des questions de physique et de mathématiques. . . . Daniel Bernoulli obtint le prix dix fois" (Maury, p 171). Among the celebrated Éloges by Fontenelle there are those of Leibniz, of Peter the Great, of Newton, of Marsigli, of Boerhaave, among those by Condorcet there are those of Haller, Linnæus, Hunter, and Euler; among Cuvier's there are those of Gilbert, Priestley, De Saussure, Cavendish, Pallas, Rumford, Werner Banks, and Davy.

[3] "Jusqu'à présent," says Fontenelle in 1699, "l'Académie des Sciences ne prend la nature que par petites parcelles. Nul système général, de peur de tomber dans l'inconvénient des systèmes précipités dont l'impatience de l'esprit humain ne s'accommode que trop bien, et qui, étant une fois établis, s'opposent aux vérités qui surviennent" (quoted by Flourens, 'Éloges,' vol. iii. p. 19) "L'esprit de l'Académie des Sciences a donc toujours été l'esprit d'expérience, d'étude directe, d'observation précise, l'amour de la certitude. D'abord cartésienne, elle devint ensuite Newtonienne," &c. (ibid., p. 21) Fontenelle contrasts the "philosophie des mots et celle des choses, de l'École et de l'Académie" ('Éloge de Du Hamel' in Bouillier, p. 10). "Fontenelle se plaît à multiplier les exemples de cette incapacité chez les savants de faire fortune et de ce noble désintéressement" "Il aimait mieux

operation of many minds in rearing the great edifice of science, and found a place for the minutest research, as well as a field for the development and sway of great and governing ideas. Of the best form of this spirit and system—the Académie—Cuvier was the greatest representative. Through several dozen Éloges which he pronounced on the decease of a number of the most illustrious scientific men of Europe, as well as through several Reports, in which he summed up the labours and progress of his age, and the peculiar features of his period, he affords to the student of history an insight into that distinctive phase which scientific thought had entered in France at the end of the eighteenth century. This he allows us to contrast with other phases of thought, such as the philosophical or individual, which obtained in other ages or countries, and suggests as well as gives the means of answering the question, to what extent the scientific ideal

étudier que subsister," he said of one of the Academicians (Bouillier, pp ix, xii). Cuvier was very watchful over the Academy in keeping out the speculative spirit. See what he says in the joint Report on geology with Hauy and Lelièvre ('Mém. de l'Institut,' vol. viii. 1607, p. 136). "Que doivent donc faire les corps savans pour procurer à une science aussi intéressante et aussi utile, les accroissemens dont elle est susceptible? . . . Ils doivent tenir la conduite, qu'ils ont tenue depuis leur établissement, à l'égard de toutes les autres sciences: encourager de leurs éloges ceux qui constatent des faits positifs et garder un silence absolu sur les systèmes qui se succèdent." Compare with this what he says about the use of the principle of "vital force," always referring to Newton's method ('Mém. de l'Inst.,' vol. vii. p. 77, &c.), further in his analysis of Gall and Spurzheim's Mémoire ('Mém. de l'Inst.,' vol. ix. p. 65). "Les commissaires de la classe . . . ont donné leur assentiment à presque toutes les propositions de MM. G. & S., qui ne dépendent que de l'inspection anatomique, &c. . . . les commissaires ont cru également de leur devoir de prévenir le public, qu'il n'y a aucun rapport direct, aucune liaison necessaire entre ces découvertes et le doctrine enseignée par MM. G. & S., &c. . . Toutes ces matières sont encore trop étrangères aux attributions de la classe, elles tiennent aux faits sensibles d'une manière trop lâche, elles prêtent à trop de discussions vagues, pour qu'un corps tel que le nôtre doive s'en occuper" (p. 159).

of the end of this century agrees with or differs from that of its beginning. Upholding the Newtonian rather than the Baconian and Leibnizian standard in the mathematical and physical sciences,[1] he has marked that line which our whole century has contributed to trace out more distinctly; whilst, as regards the purely natural sciences, his continued emphasising of the great problem of organisation, and his later controversy with Geoffroy de Saint-Hilaire, mark that point in which this century has most distinctly departed from the prevailing ideas of its early years.[2] He also recognised earlier than any other mind of similar eminence what our century increasingly realises, how, without a system of condensation, contained in reports, statistics, and figures, aided by classifications and systems, the growing bulk of accumulated knowledge becomes chaotic and unmanageable.[3]

[1] Cuvier was not brought up in the school of the Encyclopædists, and I cannot find that he attached the great importance to the writings of Bacon which that school commonly did As to Newton and Leibniz, he contrasts their methods, considering them "comme les chefs et les représentans des deux méthodes opposées qui se sont disputé l'empire de la science" ('Histoire des Sciences naturelles,' publiée par Magdeleine de Saint-Agy, Paris, 1841, vol. iii. p. 19, &c.) See also in his joint Report with Hauy and Lelièvre on the Science of Geology ('Mém. de l'Institut,' 1807, p 133): "On vit renaître dans cette partie de l'histoire naturelle la méthode systématique de Descartes, que Newton semblait avoir bannie pour jamais de toutes les sciences physiques, . . . et lorsqu'on songe que Leibniz et Buffon sont au nombre des philosophes dont je parle ici," &c.

[2] A future chapter will deal specially with this subject. Cuvier, as is well known, maintained the fixity of species, and opposed the theories of St Hilaire and Lamarck, in which a later generation recognises the beginnings of the Darwinian doctrine of the transmutation of species. "On est obligé d'admettre certaines formes, qui se sont perpétuées depuis l'origine des choses, sans excéder ces limites; et tous les êtres appartenans à l'une de ces formes constituent ce que l'on appelle une espèce" ('Règne animal,' vol i p. 20).

[3] Cuvier was the first great scientific writer who undertook to give a historical survey of the position of the different natural sciences, with a view of ascertaining what had been achieved and what remained to be done He did what

Cuvier had also a true historical sense, which enabled him to trace the connection of science with political history, with literature, with the fine and useful arts. And he helps to answer a question which to us is of paramount interest, How did science fare during the great cataclysm of the Revolution? how under the reactionary despotism of the First Empire? Before attempting to reply to these questions in the light of subsequent and general European history, I will select a few passages from Cuvier which throw light upon these points:[1]—

31. On the fortunes of science during the Revolution and the First Empire

"There is always a revolution required in order to change habits which have become general, and the most necessary revolutions do not take place without some circumstance, which is sometimes long delayed. We have been able to see how in such a case everything furthers the sciences, even the delays and contrarieties which they seem to suffer under.

"The events which disturbed the world, and which for natural science temporarily dried up the sources of its riches,[2] obliged it to return to itself, and to make a new study of what it possessed, more fruitful than the most

a generation later the British Association undertook to do, and what in Germany the many "Jahresberichte" do nowadays. See his "Analyse des Travaux," &c., 'Mém. de l'Institut,' vol. ix. p 53, and his celebrated 'Rapport historique sur le Progrès des Sciences naturelles depuis 1789,' Paris, 1810.

[1] 'Éloges historiques,' vol. iii. p. 456, 1824.

[2] This refers to the isolation of France during the war and the Continental blockade, which deprived it of foreign imports and the scientific collections of foreign specimens; see also 'Éloges,' vol. i. p. 9; vol. iii. p. 202: "Quand la jalousie des peuples nous privait des produits étrangers, la chimie les faisait éclore de notre sol" "Le conseil des mines établi en 1793, lorsque l'interruption de tout rapport avec l'étranger fit sentir le besoin de tirer parti de notre territoire a donné à ces sortes de recherches une impulsion toute nouvelle" ('Rapport,' p 178).

fortunate departures could have been. During this apparent rest, all the different parts of method were deepened, the interior of natural objects was studied, even minerals were dissected and reduced to their mechanical elements, a still more intimate analysis was made by a perfected chemistry; the earth itself was, during this interval, if the expression is allowable, dissected by the geologists; its depths were sounded; the order and layers of rock which form its shell were recognised.[1] In the absence of foreign contributions the interior of the soil on which we walk became tributary to science. The beings of which it contains the remains came to light, and revealed a natural history anterior to that of to-day, different in its forms, and nevertheless subject to similar laws, thus giving to these laws a sanction which no one expected. The botanists did not gather so many plants in their collections, but with the lens in hand they demonstrated more and more the intimate structure of the fruit, the seed, the various relations which connect the parts of the flower, and the indications which these relations furnish for a natural division. The most delicate forms of organic tissues were exhibited; medicine

[1] Cuvier refers here to the investigation of the fossils in the Paris basin, which he undertook during the years 1804 to 1808: "La singularité des animaux dont je découvrais les ossements à Montmartre me fit désirer de connaître plus en détail la composition géologique des environs de Paris. Mon ami Brongniart s'associa à moi pour ce travail; nous fîmes ensemble et séparément beaucoup de courses. . . . Ces recherches ont donné une face toute nouvelle à la géologie, et ont occasionné toutes celles qu'ont faites ensuite en Angleterre MM Webster, Buckland, Labêche et autres" (Cuvier, "Mém. sur sa Vie" in Flourens, 'Eloges,' vol. iii. p. 188). This was the beginning of the Science of Palæontology, a term which Cuvier did not use himself (Flourens, 'Travaux de Cuvier,' p. 147). See also Cuvier, 'Recherches sur les Ossemens fossils de Quadrupèdes,' &c, 1st ed., 1812, 3rd ed., 1825, in the Introduction

and chemistry united their efforts to appreciate in the minutest detail the action of external elements on the living organism.[1] The different combinations of organs, or what we call the different classes, the different genera, were not less studied than general theories. There were no animals, ever so small, the inner parts of which, unveiled by anatomy, did not become known as well as our own. Every organic system was likewise submitted to a special examination. The brain, marking the degree of intellectual power; the teeth, signs of the nature and energy of the digestive forces; the bony system, above all, which is the support of all others, and which determines the connected forms of animals, —all these were followed into the smallest species and into the minutest parts. We see how, after such studies, there could be no more talk of superficial or artificial methods. The old natural history had ceased to rule. It was not that old natural history any more, but a science full of life and youth, armed with quite novel ways and means, which beheld the world reopened by the Peace."[2]

In an earlier passage,[3] speaking of the reopening of academies and schools by the Government of the Revolu-

[1] Compare with this the 'Rapport' of the year 1808, p. 201, &c. The above remarks refer mainly to Bichat. "Bichat a donné à l'anatomie un grand intérêt, par l'opposition de structure et de forme qu'il a développée, entre les organes de la vie animale, c'est-à-dire, du sentiment et du mouvement, et ceux de la vie purement végétative. . . . L'attention particulière donnée par Bichat au tissu et aux fonctions des diverses membranes, et l'analogie qu'il a établie entre celles de parties très éloignées, ont jeté aussi des lumières nouvelles sur l'anatomie, principalement dans ses rapports avec la médecine" ('Rapport,' p. 218).

[2] This refers to the peace which concluded the Napoleonic wars, and re-established the free intercourse of France with the rest of the world.

[3] In the 'Éloge of Fourcroy," of the year 1811 ('Éloges,' vol. ii. p. 40, &c.)

tion, Cuvier remarks: "It was not merely a question of isolated discoveries, but of institutions, which, in assuring the conservation of the sciences, would multiply their progress indefinitely. What was needed was no longer a simple experimenter, master of his subject and his instruments, it was a man obliged to battle against all kinds of obstacles, and to benefit his fellow-citizens, mostly in spite of themselves. The Convention had destroyed academies, colleges, universities; nobody would have dared to ask boldly for their restitution, but soon the effects of their suppression showed themselves in the most susceptible point; the armies were without doctors and surgeons, and these could not be created without schools.[1] But who would believe that time was required to give courage enough to call them schools of medicine. Doctor and surgeon were titles too contrary to equality, apparently because there is no authority over the patient more necessary than that of the doctor; therefore the odd term "schools of health" was used, and there was no question of either examination or diploma for the students. In spite of this, a penetrating glance reveals, in the regulations which were carried, the intentions of him (Fourcroy) who drew them up. The three great schools founded at

[1] See 'Éloges,' vol i. p. 353. "Cependant les gens qui avaient fait toutes ces suppressions eurent promptement lieu de s'apercevoir que, s'il était à la rigueur superflu d'apprendre toute autre chose, on ne pouvait guère se dispenser d'apprendre la médecine. Toute la France se précipitait aux frontières, et, après des prodiges inouis de dévouement et de valeur, les défenseurs de la patrie ne trouvaient aucun secours pour leurs blessures et pour leurs maladies. On commença donc par l'érection des écoles de médecine cette longue suite de restaurations, que l'établissement de l'université vient de couronner et de lier en un ensemble aussi imposant par l'étendue de son plan que par la vigueur de son organisation." See also 'Rapport,' &c., p. 360.

this epoch,[1] received an abundance of means, of which up to that time there was no idea in France, and which still form the finest ornament of the University."

Similar passages might be collected in which Cuvier enlarges on the influence of war and revolutions, of the Continental blockade and the isolation of the country; on the reconstruction of hospitals and the admission of medical science into the Academy; on the creation of new industries; on the development of the mining and mineral wealth of the country; on the scientific value of colonies and travels, and many other interesting topics. In confining myself more closely to the history of thought and the growth of the modern scientific spirit, I will make some reflections which his remarks force upon us.

.32 France has done more than other countries to popularise science

I have noted above how France more than any other country worked for the popularisation of science, how her polite literature alone during the eighteenth century bears the strong impress of modern scientific ideas; no other country has a Fontenelle, a Voltaire, a Buffon. This peculiarity must be recognised as a very powerful and valuable stimulus to the growth of the scientific spirit. It emanates largely, if not exclusively, from the peculiar position of the old Academy of Science. It must, however, not be forgotten that it was not a popularisation of the kind we witness nowadays.

33. Difference between the literary and the national popularisation.

The class of literature which in our age spreads broadcast the discoveries or ideas of science; the endless number of magazines, reviews, and daily papers; the small treatises, the cheap primers, the compact text-books, did

[1] They were the three "Écoles de Santé" at Paris, Strasbourg, and Montpellier (see Hippeau, 'L'Instruction publique en France,' vol. ii. p. 194).

not then exist.[1] Science was not a subject of general, still less of popular, instruction. It was an occupation of the few, who, privileged by fortune or talent, or gifted with inordinate perseverance, forced their way into the *salons* of society[2] or the rooms of the Academy. The first public course of natural history was opened in Paris by Valmont de Bomare in 1760.[3] Science still stood far out of the reach of the practical man or the poor man; it had not yet become an element of education or an instrument for industry. It was a fashionable pursuit, a luxury of the great, a key that occasionally opened the door of the palace; but it was not a thing of immediate use, except in adding glory and renown to its royal protectors, or to the rare genius which could make new discoveries. Almost the only application made of it was in navigation, and in the construction of instruments connected therewith. This essentially literary—not national—popularisation of science had also its great dangers. No ideas lend themselves to such easy, but likewise to such shallow, generalisations as those of science. Once let out of the hand which uses them, in the strict and cautious manner by which alone they lead to valuable results, they are apt to work mischief. Because the tool is so sharp, the object to which it is applied seems to be

34. Dangers of the merely literary popularisation.

[1] Cuvier, in his 'Rapport,' &c., p. 361, mentions the elementary works published by some of the medical professors at the beginning of the century, but says also that "En Allemagne, surtout, où l'usage des livres élémentaires est plus commun que chez nous, il n'est presque aucune université, dont les professeurs n'en aient publié d'excellens."

[2] See Maury, p. 182, &c. Also Cuvier, 'Rapport,' vol. ii. p. 427: "En France la réputation des ouvrages dépend, pour l'ordinaire, des femmes et de quelques gens de lettres, qui croient pouvoir juger des sciences positives, parce qu'ils ont combiné quelques idées générales de métaphysique."

[3] See Maury, 'L'ancienne Académie des Sciences,' p. 283.

so easily handled. The correct use of scientific ideas is only learned by patient training, and should be governed by the not easily acquired habit of self-restraint. It is well known how the fundamental notions of a mechanical science, let loose into literature by Fontenelle, by D'Alembert, by Condorcet, or absorbed by Voltaire and Diderot, were expanded into a system of materialistic philosophy in 'L'Homme Machine,' the 'Système de la Nature,' and other works, the extreme views of which the great scientific thinkers could hardly approve of.[1] These hasty but

[1] As a great deal of confusion existed for a long time in European literature as to the exact succession in time of the different works which assisted to spread mechanical views of the world and of life, I put down the main dates:—

Fontenelle (1657-1757) published his Eloges of the great Academicians, in which the principles of the philosophy of Descartes, Leibniz, and Newton were popularly expounded and discussed, from 1700 onward His 'Pluralité des Mondes' had appeared already in 1686; it had popularised Cartesian ideas

Voltaire (1694-1778) published his 'Élémens de la Philosophie de Newton' in 1738

La Mettrie (1709-51) published his 'Histoire naturelle de l'Âme' in 1745, and his 'L'Homme Machine' in 1748.

D'Alembert and Diderot published the first volume of the 'Encyclopédie' in 1751.

Buffon (1707-88) published, 1749, his 'Théorie de la Terre,' being the first portion of the 'Histoire naturelle'

Holbach (1723-89) published under the name of Mirabaud, 1770, the 'Système de la Nature.'

Of these works, the three which created the greatest popular sensation — *viz.*, Voltaire's 'Élémens,' La Mettrie's 'L'Homme Machine,' and Holbach's 'Système'—were all published in Holland. Voltaire, D'Alembert, and Diderot appear to have approached philosophical problems mainly from the position of Newton's natural philosophy, La Mettrie from the teachings of the great Boerhaave, Holbach principally from a study of chemistry. It is unnecessary to say that none of them had the sanction of their great masters for the applications they made of principles which had been established and used for special scientific purposes And the same may be said with reference to the influence of Locke, which in almost all the instances mentioned was combined with that of the great naturalists. But this does not belong to the line of thought in which we are interested at present. For the sake of completeness only I mention that Locke's teachings as well as Newton's were made popularly known in France by Voltaire's "Lettres sur les Anglais' (burnt by order of the Parliament of Paris in 1734), whereas Condillac's (1714-80) more systematic treatise, entitled 'Essai sur l'Origine des Connaissances humaines,' appeared in 1746. It is

brilliant generalisations, expressed frequently in the most perfect language, did no good to the truly scientific cause; they did not spread the genuine scientific spirit. Much of the good done by Fontenelle, by Voltaire, by Buffon, was spoiled or neutralised by premature and ill-founded theories. How much, or how little, they contributed (either directly or by a kind of reaction which set in against them, of which Rousseau may be regarded as the centre) to bring about the Revolution is a matter of much controversy; certain it is that the Revolution broke their sway, and destroyed their immediate influence.[1] To the purely literary the Revolution added

35 The Revolution added the modern practical popularisation of science

important, in dealing with the extreme materialistic writings which French literature produced between 1745 and 1770, to keep distinct the different origins from which they started, and the different influences which combined to produce them: the mathematical and mechanical principles borrowed from Newton, the physiological and medical emanating from Linnæus and Boerhaave, and the psychological coming from Locke and Shaftesbury Lange, in his 'History of Materialism' (transl. by Thomas, London, 1880, 3 vols.), was the first to point out clearly the correct chronology and succession of these writings (see especially vol. ii. pp 49-123), and to dispel the misconceptions which, since the appearance of Hegel's 'Geschichte der Philosophie' in 1833-36, had passed through nearly all historical works published in Germany. From his exhaustive references, it is evident that the extreme views of La Mettrie, Diderot, and Holbach cannot be fathered on any of the great scientists or philosophers, but were an attempt to apply scientific principles to the solution of philosophical, ethical, or religious questions, frequently for practical and political purposes

[1] It would probably be more correct to say that these daring attempts to deal with the general problems of knowing and being, with the nature of the soul and the conduct of life, were discarded as premature, and that the followers of Condillac and Locke betook themselves to a more patient study of the facts of the inner life, as the followers of Buffon forsook his brilliant generalisations for the more patient and fruitful study of all the forms of physical nature. And in this respect the Government of the Revolution took a memorable step when it founded on the 3rd brumaire, an iv. (25th October 1795), on a Report of Daunou, based mainly on ideas expounded by Condorcet, the "Académie des Sciences morales et politiques." It was the intention to abandon metaphysical generalisations, and to combine the scientific and historical spirit in the study of mental, moral, and social phenomena, drawing extensively on the assistance of the medical sciences, or a knowledge of human nature in its nor-

something different—*viz.*, the modern practical popularisation of science. It established its educational and its technical importance. Science was to be not an elegant amusement, or a refined luxury, nor even exclusively the serious occupation of the rare genius: it was to be the basis of a national instruction, and the foundation of the greatness and wealth of the nation. The Memoirs of the Academy were cleansed of all dangerous generalisations which might have brought them into touch with political controversy; the language was confined to the measured and concise statement of facts, or to theories capable of mathematical verification and treatment; conjectural matter was carefully excluded, and a standard of scientific excellence, both in matter and form, was raised, to which we still look up with admiration.[1] At the same time, this lofty and dignified spirit enlivened the courses

mal and diseased conditions. This organisation produced, during its short existence of only seven years, some memorable works; but its position was for various reasons secondary only: it was eclipsed by the European renown which the "Académie des Sciences" possessed, owing to its historical antecedents and its brilliant discoveries and the practical usefulness of its labours. But the idea of including ethical and political studies under the term "Science," due probably to Condorcet, was fixed by this organisation, and has in the course of the century acquired increasing influence. From these beginnings we shall have to study its career in another portion of the present work.

[1] According to Cuvier, "la langue naturelle de l'Académie des Sciences" is "la langue des chiffres" ('Éloges,' vol. i p. 24); "l'Académie a toujours eu pour principe de ne se rendre qu'à des calculs ou à des expériences positives" (vol. iii. p. 12). Compare also 'Mém de l'Institut,' vol. vii. p. 77, where he speaks of the method of Newton, showing how little the employment of a principle like that of "vital force" in physiology can be compared with that of gravitation, employed by Newton to explain the movement of the heavenly bodies; again, vol. viii. p. 139, where he refers to the great service rendered by the Academy, "s'il parvenait à diriger les esprits vers des recherches positives, mais longues et pénibles." And vol. ix p. 61. "On aime toujours à voir se multiplier dans les sciences expérimentales les moyens simples d'arriver à la précision et de se rapprocher des sciences mathématiques," and other passages quoted above, p. 115 and p. 128 See also his remarks on the Philosophy of Nature, 'Rapport,' p. 335.

of lectures delivered in the great schools by the first men of the nation, and became, through them, the habit of a large number of ardent pupils, who were to carry it further into more popular teaching, or into the applications of art and industry.[1] The results of both are well known. We still live, at the end of the century, under their immediate influence. If now we continually appeal to scientific authorities for aid in the solution of practical problems, it is well to remember that nothing helped more to raise science to the eminence of a great social power than the action of the Revolutionary Government in 1793. Whilst it guillotined Lavoisier, Bailly, and Cousin; drove Condorcet to suicide, and others like Vicq-d'Azyr and Dionis du Séjour into premature death;[2] it had to ap-

[1] See Cuvier, "Réflexions sur les Sciences," 1816, in 'Éloges,' &c., vol. i. p. 24, &c.: "Que l'on recherche, ce qu'ont valu à la France depuis vingt ans les inventions pratiques dérivées des découvertes de MM Berthollet, Chaptal, Vauquelin, Thénard, &c., dans la seule chimie minérale, dans cette branche assez bornée des sciences physiques; l'extraction de la soude, la fabrication de l'alun, du sel ammoniac, des oxydes de plomb, des acides minéraux, toutes substances que nous tirions de l'étranger; l'épuration des fers, la cémentation de l'acier et enfin le développement des arts qui emploient ces matières premières: il est clair que c'est par centaines de millions qu'il faudra calculer." Also, vol. iii. p 202: "Les applications de la science à la pratique avaient fait de M Berthollet, lorsque la guerre de la révolution éclata, le chimiste le plus connu du public, après Lavoisier; et il était presque impossible que l'on ne recourût pas à lui au moment où la chimie devint pour la guerre un auxiliaire de première necessité, et lorsqu'il fallut demander à notre sol le salpêtre, la potasse et jusqu'aux matières colorantes; qu'il fallut apprendre à faire en quelques jours toutes les opérations des arts. Chacun se souvient de cette prodigieuse et subite activité qui étonna l'Europe, et arracha des éloges même aux ennemis qu'elle arrêta. M. Berthollet et son ami M. Monge en furent l'âme."

[2] Vicq-d'Azyr (1748-94), the great forerunner of Cuvier in the new science of comparative anatomy, "au sortir d'une de ces parodies sinistres décorées du nom de fête nationale, était saisi d'un mal qui l'enlevait en quelques instants dans le délire de la peur. Dionis du Séjour (1734-94), après deux années d'effroi et de misère, ne trouvait plus assez de force pour goûter les temps moins malheureux amenés par la chute de Robespierre" (Maury, 'Les Académies d'autrefois,' vol. i. p. 332).

peal for its most necessary requirements to the society of scientific authorities, which it professed not to need. "Everything," says the historian of the Academy,[1] "was wanting for the defence of the country—powder, cannons, provisions. The arsenals were empty, steel was no longer imported from abroad, saltpetre came not from India. It was exactly those men whose labours had been proscribed who could give to France what she wanted. Fourcroy, assisted by researches begun by Lavoisier, taught the methods of extracting and refining saltpetre; Guyton de Morveau and Berthollet made known a new method of manufacturing gunpowder, and studied the making of iron and steel; Monge explained the art of casting and boring cannons of brass for land use, and cast-iron cannons for the navy. On the 6th of August 1793 the Convention had again to appeal to the Academy in order to know what advantage it would be to refine as much as possible the coins of the Republic?" In the space of a few years science had become a necessity to society at large.[2] In the Constitution of the regenerated Academies it was placed at the head, as the most important department of knowledge.

[1] Maury, *loc cit.*, vol. i. p 329. See also Biot's 'Essai sur l'Histoire générale des Sciences pendant la Révolution française.' Paris, 1803

[2] The last entry in the record of the "procès-verbaux de l'Académie" before the suspension was a Report by Borda, Laplace, and Lagrange, in answer to a demand of the Convention, dated 19th January 1793, for advice on the new system of weights and measures which the Republic should adopt. And so necessary had the assistance of men of science become to the Government, that even during the suspension, which lasted from the 8th August 1793 till the 22nd August 1795, Lakanal had succeeded in procuring the following decree from the Government of the Convention: "La Convention nationale décrète que les membres de la ci-devant Académie des Sciences continueront de s'assembler dans le lieu ordinaire de leurs séances, pour s'occuper spécialement des objets qui leur auront été ou pourront leur être renvoyés par la Convention nationale" (Maury, *loc. cit.*, p. 331; Aucoc, 'L'Institut de France,' p. ccvii, &c.)

36. Influence of the first Napoleon on science

The influence of the first Napoleon on science is naturally a matter of as much controversy as his merit in almost every branch of administration. The reports[1]

[1] According to a decree of the Government, dated 13th ventôse, an x. (4th March 1802), the Institute, then consisting of three classes—the "Académie des Sciences physiques et mathématiques," the "Académie des Sciences morales et politiques," and the "Académie de Littérature et Beaux-arts"—was ordered to furnish "un tableau de l'état et des progrès des sciences, des lettres et des arts, depuis 1789 jusqu'au 1re vendémiaire an x." This "tableau" was to be divided into three parts according to the three classes of the Institute. These Reports were to be repeated every five years. The first (and only) Reports were not presented before February and March 1808. The Republican Government had then been superseded by the Empire, and by a decree of the 3rd pluviôse, an xi. (23rd January 1803), the Institute had been reorganised. There were now four classes: 1. Des Sciences physiques et mathématiques (corresponding to the old Académie des Sciences). 2. De la langue et de la littérature françaises (corresponding to the old Académie française). 3. D'histoire et de littérature ancienne (corresponding to the "Académie d'Inscriptions et de Belles-lettres"). 4. Des beaux-arts. "On supprima la classe des sciences morales et politiques qui existait dans l'organisation du 3 brumaire, an iv. Ce fut un trait caractéristique de la répugnance du premier Consul pour la discussion des matières politiques et leur enseignement" (Thibaudeau, 'Le Consulat et l'Empire,' Paris, 1835-37, vol. iii. p. 396). Accordingly there were prepared four, or rather five, Reports, the first in two parts by Delambre and Cuvier on the progress of the Mathematical and Physical Sciences; the second by Marie-Joseph Chénier on the progress of Literature; the third by Dacier on the progress of History and Classical Literature; the fourth by Le Breton on Fine Arts. Of these the two Reports of Delambre and Cuvier gave great satisfaction, that of Dacier gave less satisfaction; Chénier, who himself admired the eighteenth-century philosophy, had an embarrassing task to perform, of which, however, he acquitted himself worthily (Thibaudeau, *loc. cit.*, vol. vi. p. 557). The Report of Chénier has been several times reprinted. The new science which was founded by Condillac, Turgot, Condorcet, and others, and which aimed at introducing the truly scientific spirit into psychology, psycho-physical researches, and questions of society and legislation, received no recognition, as it had also lost its representation in the suspended "Académie des Sciences morales et politiques." After the re-establishment of this section of the Institute in 1832, a royal decree of 22nd March 1840 ordered a Report on the progress of the Moral and Political Sciences from 1789 to 1832. The task was so great that it could not be accomplished before the Revolution of 1848, and was therefore abandoned (Aucoc, 'L'Institut de France,' pp. 62 note, 300). Some reference to the subject is contained in the introduction to Chénier's Report, and in the last chapter of Dacier's, which was written by De Gérando. The true history of the new science has been recently written by F. Picavet, 'Les Idéologues,' Paris, 1891.

which Delambre and Cuvier drew up at his request, touching the progress of science during the twenty years which followed the outbreak of the Revolution, have become classical as monuments of the achievements of a great age,[1] and as examples of the best style in which to treat such a subject. Written immediately under his eye, they cannot be considered quite impartial, so far as the tone is concerned in which they refer to his personal favours and protection.[2] There can, however, be no doubt that he recognised scientific merit, and drew many eminent men of science into the service of the Government. The institutions on which he prided himself so much,—the École Normale, the École Polytechnique, and the unfinished scheme of a great centralised Institution of Learning and Education, descending from the heights of the Institute, through the various branches of the higher and secondary into a multitude of primary schools, bearing the name of the "University,"—had either existed, or been planned before him.[3]

[1] Napoleon in discussing at the council meeting the decree which ordered the several reports, said to Regnaud: "Soignez bien cette rédaction, car elle sera examinée par les pédagogues de toute l'Europe" (Thibaudeau, *loc cit.*, vol. ii. p. 496).

[2] See what Cuvier himself says on this subject (Mémoires, &c., in Flourens, 'Éloges,' vol. iii. p. 187) "Un rapport sur le progrès des sciences devait être présenté aux consuls en fructidor an xi. . . . Ou ne fut prêt qu'à la fin de 1807: ce n'était plus aux consuls mais à l'empereur que l'on avait à présenter le travail. Il le reçut avec un grand appareil dans la séance du conseil d'État. M. Delambre et moi présentâmes le nôtre les premiers; le 3 févr. 1808, accompagnés de Bougainville, président, et des doyens de toutes les sections. La cérémonie fut solennelle; l'empereur fit une belle réponse, qui est imprimée à la fin du rapport. Je sus le lendemain, par M. de Ségur et d'autres conseillers d'État, qu'il avait exprimé une grande satisfaction de mon rapport en particulier. 'Il m'a loué comme j'aime à l'être, dit-il.' Cependant je m'étais borné à l'inviter à imiter Alexandre et à faire tourner sa puissance au profit de l'histoire naturelle"

[3] Regarding the University, see 'Code Universitaire ou Lois, Statuts et Règlemens de l'Université Royale de France, mis en ordre par M. Ambroise Rendu.' Paris, 1808. T.

It will therefore always remain a matter of doubt to what extent he originated ideas, or merely adopted those of others before and around him. He favoured the mathematical sciences, and created great prizes for physical, notably electrical, discoveries, partly because these pursuits promised to surround his Government with glory, partly because he recognised their practical importance for the purposes of the state and nation; partly also, because he himself had had a mathematical training.[1] During his

37. Napoleon favoured the mathematical sciences

the Introduction we read as follows: "Bonaparte passait à Turin. Un jour qu'il parcourait le palais de l'Université fondée en 1771 par Charles Emmanuel III., il se fit représenter les statuts qui régissaient cette institution. Il y vit quelque chose de grand et de fort qui le frappa. . . . Tout ce plan d'éducation établi sur la base antique et impérissable de la foi chrétienne, tout cela lui plut, et il en garda la mémoire jusqu'au sein de ses triomphes en Italie et en Allemagne Rassasié enfin de gloire militaire, et songeant aux générations futures, après avoir solidement établi l'administration civile, après avoir relevé les autels et promulgué le Code Napoléon, après avoir par différentes lois, substitué les Lycées aux Écoles Centrales, régénéré les Écoles de Médecine, et créé les Écoles de Droit, il voulut fonder aussi pour la France un système entier d'instruction et d'éducation publique. Il se souvenait de l'université de Turin et l'agrandissant comme tout ce qu'il touchait, dans la double proportion de son empire et de son génie, il fit l'Université impériale."

[1] Among many references relating to this subject, I select one from Villemain, 'Souvenirs contemporains d'Histoire et de Littérature,' which in the first volume (9me éd., Paris, 1874, p 137) contains the description of a visit to the École Normale in 1812, and a discussion with Narbonne, to whom the Emperor had fully expressed his aims regarding education and learning. "L'Empereur n'est inquiet que d'une chose dans le monde, les gens qui parlent, et à leur défaut les gens qui pensent. . . . Il veut, et il me l'a dit vingt fois, que son règne soit signalé par de grands travaux d'esprit, de grands ouvrages littéraires. Être loué comme inspirateur de la science et des arts, être le chef éclatant d'une époque glorieuse pour l'esprit humain, c'est l'idée qui le flatte le plus; c'est ce qu'il a cherché par des Prix Décennaux. . . . Il veut (à l'École Normale) des études fortement classiques, l'antiquité et le siècle de Louis XIV.; puis quelques éléments de sciences mathématiques et plus tard la haute géométrie, qui est, dit-il, le sublime abstrait, comme la grande poésie, la grande éloquence est le sublime sensible." Napoleon said to Narbonne: "J'aime les sciences mathématiques et physiques; chacune d'elles, l'algèbre, la chimie, la botanique, est une belle application partielle de l'esprit humain; les lettres, c'est l'esprit humain lui-même. . . . Aussi, j'ai deux ambitions: élever la France au plus haut degré de la puissance

campaigns in Italy and Germany, and on his expeditions to Egypt and the East, he surrounded himself with some of the greatest scientific authorities, such as Berthollet and Monge. From political as well as personal motives, he discountenanced the once fashionable sensualistic philosophy. This philosophy has now fallen to the second rank, though still represented by eminent thinkers, such as Cabanis, Destutt de Tracy, Daunou and Garat. It was these thinkers of whom Napoleon sneeringly spoke under the designation of "Idéologues."[1]

38. He discountenanced the contemporary representation of philosophy.

After all that has been said by admirers to magnify, and by opponents to minimise, Napoleon's merits in promoting the cause of science, and in spreading the modern scientific spirit, I cannot but recognise that he was, amongst the great heroes and statesmen of his age, the first and foremost, if not the only one, who seemed thoroughly to realise the part which science was destined to play in

guerrière et de la conquête affermie, puis y développer, y exciter tous les travaux de la pensée sur une échelle qu'on n'a pas vue depuis Louis XIV. C'était le but de mes Prix Décennaux qu'on m'a gâtés par de petites intrigues d'*idéologues*, et de couronnements ridicules, comme celui du catéchisme de Saint-Lambert."

[1] A full account of these authors, their influence and their aims, will be found in F. Picavet, 'Les Idéologues, Essai sur l'histoire des idées et des théories scientifiques, philosophiques, religieuses, &c., en France depuis 1789,' Paris, 1891.

Thibaudeau, 'Le Consulat et l'Empire,' gives many details regarding Napoleon's connection with science, with literature, and with the growing industries of France. Among the latter see especially the great efforts made to supersede colonial and foreign goods by home productions. Prizes and encouragements of all sorts were given; technical schools and colleges were established; exhibitions were promoted. Sheep were imported from Spain, sugar was made from raisins and beetroot, saltpetre and soda by chemical processes, the *garance* or madder root and the *kermès* were to take the place of *cochenille*, the *pastel* the place of the imported indigo. That an enormous impetus was thus given to chemistry cannot be denied. (See Thibaudeau, *passim*, and especially vol. v. p. 248, &c.) See also Cuvier's 'Rapport,' &c., for an account of applications of science, especially chemistry, pp. 376-386, and Delambre, 'Rapport,' &c., pp. 326-362.

the immediate future. This part, as we know, it has played both by entirely changing the external face of things, and by running out into endless applications; and we have seen the importance of that statistical spirit of numbering, measuring, and registering, by which alone a survey of complicated phenomena is possible. Of the statistical method Napoleon himself made use on an extensive scale: perhaps he was the first among rulers to do so.[1] That the great leader of men has to recognise not only the inductive philosophy of statistics and averages, but likewise governing ideas of a different class, Napoleon was well aware, and his ultimate failure may be traced to the fact that, however great as a general and as a calculator, his soul had no room for those high, religious, and unselfish motives of which he himself said to Fontanes, that they in the end always decide the fate of nations.[2] Yet he belongs to the small company of great military figures in history—a company which includes Alexander the Great, Cæsar, and Peter the Great

39. He himself made extensive use of the statistical method.

[1] See Delambre, 'Rapport,' &c., p. 222. "Depuis le peu de temps qu'on s'en [*i e*, with statistics] occupe en France, elle y a fait les plus grands progrès, au moyen de l'attention particulière et des secours que le Gouvernement françois donne à tous les travaux utiles. Les préfets des départemens ont été invités à recueillir et à transmettre au Ministre de l'intérieur les renseignemens les plus précis sur toutes les questions qui sont du ressort de la statistique."

[2] See 'Œuvres littéraires de Napoléon Bonaparte,' vol. iii. p. 5; Conversation avec Fontanes, Saint Cloud, 19 Sept. 1808: "Fontanes, savez-vous ce que j'admire le plus dans le monde? C'est l'impuissance de la force pour organiser quelque chose. Il n'y a que deux puissances dans le monde: le sabre et l'esprit. J'entends par l'esprit les institutions civiles et religieuses. À la longue, le sabre est toujours battu par l'esprit." Also vol. iv. p. 423. "Les vraies conquêtes, les seules qui ne donnent aucun regret, sont ceux que l'on fait sur l'ignorance. L'occupation la plus honorable comme la plus utile pour les nations, c'est de contribuer à l'extension des idées humaines. La vraie puissance de la République française doit consister désormais à ne pas permettre qu'il existe une seule idée nouvelle, qui ne lui appartienne."

—who have succeeded in permanently inscribing their names in the annals of science beside those of its true and great representatives. Some of the glory of Laplace and Cuvier falls upon him. Except for this Napoleon has scarcely a place in the history of thought. In it those who were Napoleon's servants are rulers and lawgivers; it is they who enlighten our century. They were the first great exponents of the scientific spirit, nursed under the influence of the academic system. This was peculiarly a product of the French mind and culture. It is well to recall in the words of Cuvier what the scientific spirit is. At the end of the report which he presented in the year 1808 he says:[1] "These are the principal physical discoveries which have lighted up our period, and which open the century of Napoleon. What hopes do they not raise! how much does not the general spirit signify, which has brought them about, and which promises so much more for the future! All those hypotheses, all those suppositions, more or less ingenious, which had still so much sway in the first half of the last century, are now discarded by true men of science: they do not even procure for their authors a passing renown. Experiments alone, experiments that are precise, made with weights, measures, and calculation, by comparison of all substances employed and all substances obtained: this to-day is the only legitimate way of reasoning and demonstration. Thus, though the natural sciences escape the application of the calculus, they glory in being subject to the mathematical spirit, and by the wise course which they have invariably adopted, they do not expose them-

40. His scientific glory is mainly derivative.

[1] 'Rapport,' &c., p. 389.

selves to the risk of taking a backward step; all their propositions are established with certainty, and become so many solid foundations for that which remains to be built"[1]

41 Deserved prominence given to French names by Cuvier

Nor can we look upon the great prominence which Cuvier gives to French names in the course of his survey as unjust or partial. He was well aware of the contributions of other nations: no one has spoken in more generous and correct terms of Priestley and Cavendish, of Banks and Rumford, of Pallas, Werner, and Humboldt. We must admit the correctness of the remark, "that even in those departments where chance has willed that Frenchmen should not make the principal discoveries, the manner in which they have received, examined, and developed them, and followed them out into all their consequences, places their names next to those of the real inventors, and gives them in many ways the right to share in the honour."[2]

In the first decades of this century the home of the scientific spirit was France: for though not born there, it was nevertheless there nursed into full growth and vigour. But it soon set out on its wanderings through

[1] Compare also the "Réflexions sur la marche actuelle des Sciences," being the introduction to the 'Éloges historiques,' vol i p. 1, &c

[2] 'Rapport,' p. 391 It is also remarkable how clearly Cuvier here announces the defects which the teaching of science was still labouring under. Whilst he rightly praises the great Paris institutions, the medical schools, the mathematical, physical, and polytechnic establishments, the new schools of technology and agriculture, as unequalled organisations for higher instruction, he draws attention to the absence of equally efficient elementary schools and to the neglect of those provincial institutions which before that age had already done so much to disseminate knowledge and learning. At the end of our century both France and Great Britain have still only very partially supplied the wants which Cuvier so clearly defines in the beginning

other lands and nations. At the end of our century—nay, even during the whole of the second half—we find this spirit naturalised in Italy, in Germany, in England, in the north and east of Europe. There is now no science which can be named pre-eminently after one nation. All nations have contributed their share to the cosmopolitan power and influence which science possesses. They have enlarged and deepened the scientific spirit and widened its career. Thus far it has been the growth of the scientific spirit which has occupied us; we must now proceed to study its diffusion, and learn to recognise the peculiar features which Germany and England have on their part contributed In doing so, we must turn away for a moment from the academic system with which we have been specially occupied.

CHAPTER II.

THE SCIENTIFIC SPIRIT IN GERMANY.

"No Augustan epoch flowered,
No Lorenzo favours showered
Ever German Art upon;
She was not by glory nourished
And her blossom never flourished
In the rays of Royal sun."[1]

Perhaps with more correctness Schiller might, early in the century, have applied these lines to German science than to German art. If art and poetry were only slightly indebted to princely protection, German science was still less so.[2] Leibniz's scientific labours languished while he

[1] Schiller, "Die deutsche Muse."

[2] Astronomy was the only science that enjoyed some little princely favour William IV., surnamed "the Wise," son of Philip the Magnanimous of Hesse and himself Elector, was an astronomer of some note, and stood in intimate relations with Mercator, Tycho, and other astronomers. In 1561 he built himself an observatory at Cassel and appointed Rothmann to be his "Mathematicus." Frederick II. of Denmark gave Tycho a magnificent observatory, called "Uranienburg," where he laboured from 1576 to 1597, but which was subsequently destroyed. Tycho was then employed by the Emperor Rudolf II., and inaugurated the observatory in Prague (1599-1601), he made Kepler his assistant, and enabled the latter by the use of his observations to find and prove his three celebrated laws ("Astronomia nova," Prague, 1609; "Harmonices mundi," Linz, 1619; "Tabulæ Rudolphinæ," 1627) Full details will be found in Rudolf Wolf, 'Geschichte der Astronomie,' Munchen, 1877, p. 266, &c.

occupied the position of historiographer and diplomatist at the Court of Brunswick,[1] and Tobias Mayer's valuable observations were only published with the aid of English money.[2] But if the German princes did little or nothing directly for the development of science, they indirectly

1. Foundation of German universities.

[1] Leibniz (1646-1716) entered, 1676, the service of John Frederick, Duke of Hanover, as librarian and councillor. The Duke died 1679, and Ernest Augustus, who in 1692 was made Elector of Hanover, succeeded him. Leibniz's time was taken up with diplomatic and legal researches and negotiations referring to the position of the House of Hanover, and the reunion of the Protestant and Roman Catholic Churches; latterly with genealogical and antiquarian studies referring to the history of the House of Brunswick. He wrote the 'Annales imperii occidentis Brunsvicenses,' beginning with the year 768, the date of the accession of Charles the Great, from whom Leibniz proved that the House of Brunswick descended through the Italian House of Este. He carried the history down to the year 1005, closing a few days before his death with the words "quos ex tenebris eruendos aliorum diligentiæ relinquo." The work was not printed till 1843, when G. H. Pertz, the first editor of the celebrated 'Monumenta Germaniæ' founded by the great Stein, published it with an elaborate preface. Of the annoyances to which Leibniz was subjected in the course of his studies, see an account in the correspondence with the Minister von Bernstorff (1705-16), published by Doebner, Hanover, 1882, introduction. See also Guhrauer, 'Leibnitz, eine Biographie,' 2 vols., 2nd ed., Breslau, 1846. Considering the greatness of Leibniz in so many different directions, his motto is noteworthy: "Didici in mathematicis ingenio, in natura experimentis, in legibus divinis humanisque auctoritate, in historia testimoniis nitendum esse."

[2] Tobias Mayer (1723-62), born at Marbach, the birthplace of Schiller, from 1751 Professor of Economics and Mathematics at Gottingen. To use the words of Karsten Niebuhr, "Though he had never seen a big ship, he taught the English how to determine the longitude on the open sea." He competed for the great prize of £20,000 offered in 1713 by the Board of Longitude for a method of determining the longitude at sea within ½° accurately, smaller prizes being offered for an accuracy of ⅔° and 1°. The prize of £5000, and subsequently of £10,000, was awarded to Harrison in 1758 and 1764 for his chronometers. Euler and Mayer laboured in a different direction at the same subject, by publishing lunar tables and perfecting the lunar theory. After repeated revisions, Mayer sent his tables, 1755, to London, where they were submitted to Bradley, who reported favourably on them. After further corrections, and after also submitting his theory, Mayer's widow received, in 1765, £5000, Euler £3000, and the work was published, 1770, by order of the Board of Longitude, under the title 'Tabulæ motuum solis et lunæ novæ et correctæ, auctore Tob. Mayer. Quibus accedit methodus longitudinum promota eodem auctore.'

furthered her cause most powerfully by founding that great institution of culture, which more than anything else is characteristic of the German mind, in which it has found its most perfect expression, and where it can be most exhaustively studied—the system of the German universities.

2 Development of the universities by the people.

"There is no people," says Mr James Bryce, "which has given so much thought and pains to the development of its university system as the Germans have done—none which has profited so much by the services universities render—none where they play so large a part in the national life."[1] If it is correct to say that this system owed its foundation to the German princes, it is equally true that its development is the work of the German people.[2] It may be doubtful whether, without the

[1] See James Bryce's preface to the English translation of Conrad's valuable book, 'The German Universities for the last Fifty Years,' Glasgow, 1885, p. xiii.

[2] A great deal has been written about the German universities. For the purposes of a History of Thought, I confine myself to a reference to the valuable writings of F. Paulsen, 'Geschichte des gelehrten Unterrichts auf den deutschen Schulen und Universitaten,' Leipzig, 1885, and two essays in the 45th volume of Von Sybel's 'Historische Zeitschrift,' 1881. The succeeding phases of mediæval and modern, of Roman Catholic and Protestant, of the thought of the Church, the Renaissance, the classical and the modern ideals, are all reflected in the foundation and reform of the universities and high schools of Germany and the surrounding countries The *first* foundations, in imitation of the universities of Paris and of Italy, were Prague 1348, Vienna 1365, Heidelberg 1386, Cologne 1388, Erfurt 1392, Wurzburg 1402, Leipsic 1409, Rostock 1419. A *second* epoch—under the influence of the humanistic studies—begins in the middle of the fifteenth century and adds eight new foundations—Greifswald 1456, Freiburg 1457, Trier 1457, Basel 1459, Ingolstadt 1472, Tubingen 1477, Mainz 1477, Wittenberg 1502, Frankfort on the Oder 1506 (Paulsen, 'Geschichte,' p. 14). A *third* epoch begins with the Reformation. The first Protestant university is Marburg, founded by Philip of Hesse, 1524. Melanchthon's influence is everywhere decisive. Tubingen is reconstituted by Duke Ulrich 1535, Leipsic by Duke George 1539. Basel, after three years' suspension, is reopened 1532. Frankfort on the Oder is reopened by Joachim of Brandenburg 1537, who also founds the new University of Konigsberg 1541. Greifswald is

individual influence of the former, without the divided interests of the dismembered empire, without the conflicting religious views, the political and personal rivalry of the many states and sovereigns,[1] so many scattered centres of culture and learning would have sprung so early into existence; but it is not doubtful that it is owing to the common interests of the nation, to the uniting tie of the same language, the same thought, and the same aspirations, that these scattered centres have been in course of time united into a great network,[2] a vast organisation for the higher intellectual work of the nation and of mankind. The German nation may pride itself on possessing at the present moment the most

reconstituted on a Protestant foundation 1539; Rostock in 1540-50; Heidelberg by the Elector Frederick II. in 1544. Jena is founded 1558 by John Frederick, Helmstadt by Julius of Brunswick in 1568; Giessen followed in 1607, Rinteln in 1621; Altdorf in 1662. Of the greatest influence on German culture were the Dutch Protestant universities—Leyden 1575, Franeker 1585, Utrecht 1634, Harderwyk 1648; they were for a long time—as formerly the Italian universities—the goal of the young scholar's wanderings (Paulsen, p. 179) They—as well as Geneva—held a similar position to the Scotch universities (see Sir A. Grant, 'Story of the University of Edinburgh,' vol. i. pp 21, 126, 188, 213, 229, 233, 263, 274, 283, 297, &c., vol. ii. p. 263). A *fourth* epoch begins with the foundation of Halle 1694, the first really modern university (Paulsen, p. 353). The spirit of Bacon and Leibniz, represented by Thomasius, is the leading power; it is not by any means irreligious, since Francke (the so-called "pietist") is as important a factor as Thomasius. German is substituted for Latin. Other universities follow the reform, thus Konigsberg 1735, Leipsic, Wittenberg, Helmstadt, Kiel, Tubingen, &c A *fifth* epoch —the evolution of the ideal of science in the German sense, *Wissenschaft*—begins with the foundation of Gottingen in 1737. Of this more in the text.

[1] Conrad, *loc. cit.*, p. 2: "There is scarcely a stronger bond of connection between the various parts of Germany than that supplied by the universities, and in no other respect have the barriers that separated State from State been so long broken down . . . The historical development cannot be accurately traced unless the growing extent in which the south German universities are attended by students from the north be kept in view."

[2] See especially Paulsen's remarks referring to the foundation of Göttingen under George II. ('Geschichte des gelehrten Unterrichts,' p 425).

powerful and best equipped army. But this is only the creation of the present age. With greater pride it may boast of having trained in the course of centuries the largest and most efficient intellectual army, ready at any moment to take up and carry to a successful issue great scientific undertakings demanding the intense thought and labour of a few secluded students, or the combined efforts of a large number of ready workers. This army is scattered through the length and breadth of the land, and even beyond its frontiers in neighbouring countries, wherever universities and high schools are situated.[1] It is not a stationary power, but is continually on the move from south to north, from west to east, to and fro, exchanging and recruiting its forces, bringing heterogeneous elements into close contact, spreading everywhere the seed of new ideas and discoveries, and preparing new land for still more extended cultivation.

[1] The extent of the German university system cannot be estimated by the twenty universities marked on the map attached to the translation of Conrad's book, as these represent only the existing universities of the present German empire; nor yet by the forty-three universities given in the appendix, p. 290, as they contain only some of the Austrian, but none of the Swiss universities; nor even by taking up Ascherson's valuable 'Deutscher Universitats-Kalender,' which contains the German-speaking universities—thirty-four in number in 1887—but of course does not contain the names of those which have been suppressed. There are also the universities of Denmark, Norway, and Sweden, which have exchanged many important professors with Germany, and those of Holland in older, of Belgium in modern times, which have done the same thing. The Russian universities also were largely organised on German models, though since the reforms of 1863 they aim at a more national character. Brandis founded the University of Athens on German lines in 1837. The Russian University at Kasan, that "ultima musarum Thule," was founded in 1804, and Gottingen supplied its first professors. From there and from the hardly less remote Transylvanian town, Maros Vásárhely, there issued the revolution of our fundamental notions in geometry, and there is reason to believe that both Lobachévsky's and Bolyai's theories are ultimately connected with the speculations of Gauss. See Prof. A. Vasiliev's Address on Lobachévsky, translated by Halsted, p. 5 *sqq.*

It is not my intention to dwell on the history of the German universities, on the gradual growth of the university system; though every stage in that history is interesting and important if we wish to understand the inner working and usefulness of this great organisation. Neither do I wish to do more than just mention, as an equally important subject, the geography of the German universities; how through nearly fifty larger or smaller towns, in the course of six centuries, learning and higher education have been spread over the German-speaking countries of Europe. These figures alone suggest the intricacy of the subject, the many springs, the continual ebb and flow of the rising tides of ideas, the many courses of thought, the many schools of learning, the internal conflicts, the unavoidable friction, the healthy competition and rivalry, the republican spirit, the impossibility of any creeping stagnation of life, the absence of any lengthened tyranny of doctrine, of an oppressive hierarchy, or of idols of opinion and belief. I leave it to my readers to indulge in comparisons easily suggested by these different aspects, to fasten upon the strong and upon the weak points of this great system of the German universities.[1] What I wish to emphasise

3. Geographical distribution of the German universities.

[1] The migration of students as well as of eminent professors from one university to another is one of the most important features of German academic life. Thus we find the imaginative tendencies of the southern intellect represented by Hegel and Schelling in philosophy transplanted into the midst of the encyclopædic and logical sciences of the North, or into the centre of industrial Switzerland in the person of Vischer; the theological criticism of the Tubingen school wandering northward to Marburg and Berlin in Zeller; and the philological criticism of Gottfried Herrmann locating itself in Zurich in his celebrated pupil and biographer Kochly, and in Bavaria through Thiersch. Jacobi came from the lower Rhine to Munich, where also Liebig formed a centre of modern scientific celebrities. Savigny in Berlin and Thibaud in Heidelberg represent the historical and philosophical schools of German jurisprudence. Vienna for a long time was the most celebrated German training-school of practical

very strongly here is the existence in the midst of European life, all through our century, of this vast organisation for intellectual work, this great engine of thought; and to assign to it one of the foremost places among the great agencies with which we shall have to deal.

4. Full development of the German university system.

The beginning of the present century found this great institution of university education in full swing among all the German-speaking nations.[1] The eighteenth century brought it to that state of perfection in which we have been accustomed to see it. In the course of that century it outgrew its earlier and more limited phases of existence, its period of more restricted usefulness; it emancipated itself from Court and personal favouritism, from ecclesias-

medicine and surgery, whereas Berlin concentrated the great representatives of the more recent scientific developments. In the course of the last hundred years no one university has been allowed to retain for any length of time the supremacy in any single branch. The light has quickly been diffused all over the country, when once kindled at one point. How will the future compare in this respect?

[1] This is not quite the case as regards Switzerland. The city of Basel, which before the Reformation was the seat of much learning, the names of Sebastian Brandt, Reuchlin, and Erasmus being intimately connected with it, had a university from 1459. The antagonism to classical and polite literature which characterised a large section of the Reformers (see Paulsen, p. 128 *sqq.*) destroyed many flourishing centres of culture; amongst them the University of Basel, which was suspended in 1529, when the city accepted the Reformation, but reopened three years later in 1532. Geneva, though this is outside of the German-speaking area and presents a culture quite peculiar to itself, had an academy from 1559, with many celebrated professors and numerous students of theology from all countries of Europe. Lausanne, Bern, and Zurich had colleges or high schools in the seventeenth century. But down to the nineteenth century Basel remained the only university in the Continental sense. The reasons why Switzerland developed her university system so late are discussed in Tholuck, 'Das akademische Leben des 17ten Jahrhunderts,' vol. ii p. 314, &c., where also minute information is given on the several high schools of Switzerland The question is interesting, seeing that the greatest in many branches of science—such as Bernoulli, Euler, Haller, Cuvier, Steiner—have come from Switzerland, and that by reason of the names of Rousseau and Pestalozzi it has become the centre of modern ideas on education.

tical protection and influence; it acquired through the statutes of governments or special foundations larger and better secured means of subsistence, it substituted the vernacular for the Latin tongue. The circle of studies, though from early times professedly all-embracing, did not become worthily filled up and cultivated with equal and impartial care till the fourth faculty, the *philosophical faculty*, was properly developed. Theology, law, and medicine conduct their studies for practical ends and purposes; the two former especially were frequently liable to be used merely for the ends of the Church or the State; but the philosophical faculty embraces all those studies which aim at establishing truth, be this defined as merely formal or as real, as belonging to method or to knowledge. We can assign a definite date to the firm establishment of the "libertas philosophandi," and the professed introduction of the "libertas docendi" in the university programme[1]—namely, the opening (in 1734) of the University of Göttingen (inaugurated in 1737). "The foundation stone," says Professor Paulsen, "of the academic constitution is the 'libertas docendi.' On this point Von Munchhausen, whom we may call the real founder of the university, and his two advisers, Mosheim, the theologian of Helmstadt, and Bohmer, the jurist of Halle, were agreed. All 'inquisitiones,' so writes the former, choke the powers 'ingeniorum,' and spoil the beginnings of a learned society. He advises above all that the greatest care should be used in the equipment of the theological faculty. Accordingly Munchhausen laid his eye upon men whose teaching led neither to

5. The philosophical faculty.

6. The University of Gottingen.

[1] Paulsen, 'Geschichte des gelehrten Unterrichts,' p. 424, &c.

Atheismo' nor 'Naturalismo,' who neither attack the articulos fundamentales religionis evangelicæ,' nor introduce enthusiasm, nor yet evangelical popedom. Likewise the jurists received full freedom for teaching and for the expression of legal opinions, whereas at Halle, following the common rule, the Prussian interest, at least in matters of public law, was the measure of things. At Gottingen the chief stress was laid on the culture of the essentially modern sciences. In the foremost rank stood the administrative and historico-political branches where Pütter, Achenbach, Schlozer, Gatterer, Heeren, gave to the university her world-wide fame; the mathematical and scientific branches are marked by the brilliant names of Haller, Lichtenberg, Blumenbach, Kästner; the philological branches by Gesner, Heyne, Michaelis. The university met the demand for encyclopædic discourses. Münchhausen arranged in 1756 that a member of each faculty should deliver a public course on the whole field of the sciences taught there; in the philosophical faculty Gesner treated philologico-historical, Kastner physico-mathematical subjects. An 'Index Lectionum' of the year 1737 shows nine professorships: 1. Politics and Morals. 2. History of Literature. 3. History. 4. Elocution and Poetry. 5. Logic and Metaphysics. 6. Oriental Languages. 7. Mathematics and Physics. 8. Administrative Sciences; to which is added, lastly, a professorship of Philosophy without special definition."[1]

It is evident that, owing to their constitution, as well

[1] The original endowment of Gottingen was fixed at 16,000 thalers, equal to £2400. This was more than double the endowment of Halle. (Paulsen, p. 425.)

as to their number, the German universities were destined to become the most powerful organisation for the diffusion of knowledge. Further, they have been in the course of the present century more closely linked with many hundreds of high schools, and with the growing number of technical schools.[1] For both of these they had to train the teaching staff, and from the ranks of these they again largely filled their own chairs. Thus they not only combined in themselves the spirit of research and the profession of teaching, but they infused into the widely scattered teaching staff of many hundreds of

7. Relation of universities and high schools.

[1] The technical schools in Germany and Switzerland are a creation of modern times. We can distinguish three classes (1) The "Realschule" This stands in a kind of opposition to the "Latin school." The name (according to Paulsen, p 483) occurs first in Halle, where the archdeacon Semler established in 1706 a mathematical and mechanical "Realschule." J J. Hecker established at Berlin in 1739 an "economico-mathematical Realschule." The object of these schools was to teach "Realia," to introduce practical rather than learned information. A special development was the "philanthropinism" of Basedow, well known even to English readers from Lewes's Life of Goethe (see vol. i p. 276, &c.) (2) A second class embraces the "Gewerbeschulen," which may be rendered "Schools of industry." Karl Schmidt ('Geschichte der Padagogik,' vol. iv p 163) calls Beuth the founder of them in Prussia, 1817, and gives the school of Aachen as the first. They form a kind of bifurcation with the higher classes of the Gymnasia (or learned schools). They may be more specially commercial, agricultural, or military. (3) Out of these a third class — answering to the growing demand for the practical application of the higher mathematical sciences — has grown up, named polytechnic schools. The celebrated École Polytechnique of Paris has been the model. The first of this class in Germany was established at Vienna in 1816. Then followed Munich, Hanover, Karlsruhe, Stuttgart, Nurnberg, Augsburg, Darmstadt, Zurich, Aachen, latterly also Berlin (Reichsanstalt) and Brunswick (Carolinum). In many ways they equal the universities in the scientific spirit of their teaching What is wanting is the philosophical, the historical, the encyclopædic treatment In this respect they form in their best examples a contrast to the Gottingen programme. To many serious-thinking minds they indicate the gradual dissipation of the German ideal of *Wissenschaft*, the narrowing down of *Wissenschaft* to science in the English and French meaning of the word. Their danger lies in the direction of being contented with practical usefulness, as the danger of the German type of university lay in being contented with erudition.

schools the same habit—almost absent in other countries—of looking upon private study and research as a necessary qualification of the lecturer and teacher. The educational organisation of the combined universities and higher schools has thus become an equally powerful organisation for research, and for increasing knowledge. Wherever the progress of learning and science requires a large amount of detailed study inspired by a few leading ideas, or subservient to some common design and plan, the German universities and higher schools supply a well-trained army of workers, standing under the intellectual generalship of a few great leading minds. Thus it is that no nation in modern times has so many *schools of thought* and learning as Germany, and none can boast of having started and carried through such a large number of gigantic enterprises, requiring the co-operation and collective application of a numerous and well-trained staff.[1] The university system, in one word, not only teaches knowledge, but above all it teaches *research*. This is its pride and the foundation of its fame.

8. The university a training-school of research.

[1] The editions of the ancient classics brought out by Tauchnitz, Weidmann, and Teubner are well known. The collections of the Histories of all countries, begun by Heeren and Ukert and continued in this century by the publishing firm of Salomon Hirzel of Leipsic, the 'Jahresberichte,' started by Berzelius for chemistry, and now separately conducted for all the different sciences, contain summaries of the labours of the whole world systematically arranged. There is the geographical establishment of Petermann at Gotha; not to speak of publications specifically national, such as the 'Monumenta Germaniæ,' as other countries possess similar undertakings. Von Zach was the first to establish a regular international organ for astronomical observations. It was started in 1798, and soon became the "living organ of astronomy," equally appreciated by Lalande and Gauss. This "monthly" was soon succeeded by Schumacher's "weekly," the 'Astronomische Nachrichten' See Wolf, 'Geschichte der Astronomie,' p 764, &c. Humboldt's and Gauss's scheme for a network of magnetic observations all over the world was taken up by English men of science.

It is a useful and interesting task to trace intellectual developments and habits to their external causes. The centralisation of the powers and resources of a whole nation into one capital, as was the case in Rome and in Paris, may explain the brilliancy of their literatures; the more scattered and diffused culture of Greece and of Germany is likewise reflected in their many schools of thought and learning; the insular position of England has impressed its advantages and disadvantages upon her history, and has influenced her mental life. These influences have frequently been pointed out and examined. The historian of thought has another and more difficult task to perform. Habits of thought and intellectual qualities never become the property of a large number of persons unless they assume a definite form, through this they become a marketable article which can be communicated and transmitted, and in which those also can participate from whom the deeper motives and higher aims remain hidden. Every school has its watchword, in which its leading thought, its ideal, is embodied. The widely scattered and yet closely connected community of intellectual workers represented by the German university system, which covers with its network of universities and high schools the German-speaking countries of Europe, has during the period of its greatest influence developed its own special ideal, and it has expressed this in a special word—namely, the word *Wissenschaft*. Neither the French nor the English application of the word science[1] corresponds to the use or gives the meaning of the word *Wissenschaft*. This meaning cannot be defined by any

9. The ideal of *Wissenschaft*.

[1] Compare the notes at the beginning of the last chapter, p. 89, &c.

single word in the English language. Expressions such as "student of science" or "science tripos" have a meaning in English, but they would have none if translated into German. In each case the word *Wissenschaft* would require a qualification. An "Académie des Sciences" could not according to German usage exist separately beside an "Académie française" or an "Académie des Inscriptions," for it would include them.[1] Scientific treatment in England means the exact experimental or mathematical treatment of a subject: no one ever calls Bentley[2] or Gibbon[3] a great scientific writer, though in

[1] The two older academies in Paris, the "Académie des Sciences" and the "Académie des Inscriptions et Belles Lettres," covered very nearly the same ground as the modern Berlin "Academie der Wissenschaften und Kunste," which is divided into two classes, the "mathematisch-naturwissenschaftliche" and the "philosophisch-historische Classe," the two sides being equally comprised under the term *Wissenschaften*. A similar division exists in the learned societies of Vienna, Leipsic, Munich, and Gottingen.

[2] Richard Bentley (1662-1742), popularly known in England mainly through his Boyle Lectures, his controversy about the Epistles of Phalaris, and his thirty years' feud as Master of Trinity College, Cambridge, with the dons of his college, but hardly known "as the first, perhaps the only, Englishman who can be ranked with the great heroes of classical learning" (Mark Pattison, 'Ency. Brit'), was from the first recognised as a consummate genius by the scholars of Germany, by Grævius and Spanheim, who welcomed him as "novum et lucidum Britanniæ sidus," as "splendidissimum Britanniæ lumen." The many beginnings which he had laid for subsequent critical research among the ancient classical authors were taken up abroad by men like Heyne, Reiz, F. A. Wolf, Gottfried Hermann, and Friedrich Ritschl, in whose hands they have developed into a special school of philology, counting probably over a hundred representatives, many of whom have openly avowed their indebtedness to Bentley. (See Kochly, 'Gottfried Hermann,' Heidelberg, 1874, pp 115 *sqq.*, 142, 189. Ribbeck, 'Friedr. Wilh. Ritschl,' 2 vols., Leipzig, 1879 and 1881, vol. i p. 229; vol. ii pp. 111, 176, &c, 418, 429.)

[3] Gibbon (1737-94) gave a new impetus to the study of the history of Roman law through the celebrated 44th chapter of his 'Decline and Fall of the Roman Empire.' It was translated by Professor Hugo of Gottingen and Professor Warnkonig of Liège, and has been used as the text-book on Civil Law in some of the foreign universities See Smith's edition of Gibbon's History with the Notes of Milman and Guizot, chap. xliv., note Herder, Savigny, and Niebuhr stand all under the immediate influence of Gibbon, and Lessing saw

Germany each stands at the head, and forms the beginning, of a definite scientific movement. The distinction between scientific and philosophical thought which I have explained in the Introduction would be unintelligible if science were translated simply by *Wissenschaft;* the word *Wissenschaft* is not opposed to, but embraces, the word philosophy: Fichte, whose whole doctrine was, according to French and English ideas, almost the reverse of scientific, uses the word *Wissenschaftslehre* to denote and characterise his system.[1] In fact the German word for science has a much wider meaning than *science* has in French or English, it applies alike to all the studies which are cultivated under the roof of "alma mater"; it is an idea specially evolved out of the German university system, where theology, jurisprudence, medicine, and the special philosophical studies are all held to be treated "scientifically," and to form together the universal, all-embracing edifice of human knowledge.[2] Such an

10 Has been developed under the German university system.

in him kindred tendencies, though in a different direction (see Wattenbach, 'Zum Andenken Lessing's,' p. 23).

[1] Fichte (1762-1814) begins his first philosophical work, published in 1794, with the words, "Philosophy is a science," and he then proceeds to give to his philosophy the term *Wissenschaftslehre*, or general doctrine or theory of science. A further definition which he gives is as follows: "A science has a systematic form; all propositions in it hang together in one single fundamental proposition, and are united by it into a whole." It is evident that whoever approached Fichte's writings with the ideal of science, as it was established by the labours of Lavoisier and the great French academicians, would not accept these first sentences of Fichte's book. He would admit that the sciences as cultivated by the great Frenchmen had a unity of method, the exact method, the method of observation, measurement, and calculation, but not necessarily a unity of system, or a highest all-embracing proposition. It is evident that science means to Fichte something more than it meant to the Académie des Sciences: it meant *Wissenschaft*, not merely methodical, but systematic, unified knowledge.

[2] It would be an interesting task to trace in German literature from the time of Leibniz the gradual evolution of the idea of *Wissenschaft*, to see how the word has grown in pregnancy and significance till it became firmly estab-

idea, the use of such a term, could only be born and developed where the different faculties, the various branches of knowledge, lived habitually, for many ages, under the same roof, coming into continual contact, and learning to regard each other as members of one family, as integral parts of one whole. The German university

lished as denoting a moral as much as an intellectual ideal, which it was the duty of the German university to uphold and to realise. Such an investigation would have to show how the encyclopædic view is represented by Leibniz, how Winckelmann applied the term to the studies of antiquity, how Lessing taught method and clearness, how Herder widened and deepened the view, extending it to the elemental forces as well as to the finished forms of human culture, how it was finally raised as the standard of German university teaching by F A. Wolf and W. von Humboldt, finding an eloquent exposition in Fichte's lectures on the "Nature of the Scholar" ('Vorlesungen uber das Wesen des Gelehrten,' Erlangen, 1805), and a practical realisation in the foundation of the University of Berlin in 1809, during the period of Germany's greatest degradation. The following words of Fichte have reverberated in the soul of many a German scholar to whom Fichte's philosophy was unknown or distasteful, and this same spirit has leavened and united studies which stand apparently in no connection with each other. "The scholar" (and specifically the teacher of scholars) "shows his respect for science [*Wissenschaft*] as such and because it is science, for science generally as one and the same divine Idea in all the various branches and forms in which it appears." Of one who may be seduced into overestimating his own branch, Fichte says "It becomes evident that he has never conceived science as One, that he has not comprehended his own branch as coming out of this One, that he thus does not himself love his branch as science but only as a trade; this love of a trade may otherwise be quite laudable, but in science it excludes at once from the name of a scholar. . . . In the academic teacher science is to speak, not the teacher himself," he is to speak to "his hearers not as his hearers but as future servants of science," he is to represent the dignity of science to coming generations (Fichte, Werke, vol. vi. p. 436, &c.) I have myself heard expressions similiar to these from the mouth of one who represented what we should now consider the very opposite phase of nineteenth-century thought, from one of the earliest representatives in Germany of exact research, Wilhelm Weber of Gottingen. Driven into a corner by the questionings of devoted friends as to his own discoveries and contributions, which he was modestly fond of tracing to Gauss, and unable to deny his own part, he would warmly exclaim, "But is it not possible that science could do something herself?" Professor Adamson has pointed out ('Fichte,' in "Philos. Classics,' p. 79) how the fundamental idea in these writings of Fichte has been made familiar to English readers through the teaching of England's greatest modern moralist, Carlyle.

system has the merit of having elaborated the widest conception of science, of having fixed the highest and most general scientific standards. Opposed to science is that which is unscientific, dilettante, popular; that which is not a vocation, but a handicraft; that which grows and lives outside of the great university system, including in this the innumerable learned schools which form its base, and the academy which forms its summit.

11. In France and England "Science" means "Exact Science"

What France and England have elaborated and termed Science, is called in Germany Exact Science; but it is opposed to the German ideal of science to hold that the exact method is the only method which deserves to be called scientific.[1]

[1] This is perhaps not quite correct. No doubt the term "exact Sciences" is used frequently during the last half-century to denote the mathematical and experimental sciences; very much in the same sense as we see them defined by Cuvier in the beginning of the century, and described as the ground covered by the labours of the "Académie des Sciences." There exists, however, in Germany another school of thought, very influential throughout this century, and one that has exerted a very wide and wholesome influence, which stands in no connection whatever with the mathematical sciences, though it applies the word "exact" to its methods and researches. This is the school which maintains that the real introduction to the study of antiquity lies in a knowledge of the ancient, preeminently the classical, languages, as exact and precise as any mathematical knowledge could be, and sees in an acquisition of such precise knowledge the training necessary for success in philological and historical research, just as familiarity with mathematical formulæ and measuring instruments has long been considered quite indispensable training to success in the natural sciences. Of this view Gottfried Hermann may be considered as a somewhat one-sided, Friedrich Ritschl as a more profound and far-seeing, but equally energetic representative It is Ritschl who was the most influential. Without at present entering into the controversies which existed between what were termed the "Sprach-philologen" and the "Sach-philologen," I desire here to refer to the fact that such very different representatives of thought as Fichte, Weber, and Ritschl, than whom no men could be more dissimilar in cast of mind, all find their ideal expressed in the word *Wissenschaft.* I have quoted Fichte, the speculative generaliser, and Weber, the exact mathematical physicist. I will add what Ritschl, the critical philologist, says. He trusted, as his biographer reports, "in the indestructible magnetic force of

Before the methods of exact science were introduced into Germany under English and French influences, the Germans possessed many scientific methods. There was the science of philosophical criticism, established by Kant; the science of historical criticism, of Biblical criticism; the science of philology: all these professed to have methods as definite, aims as lofty, and a style as pure, as the exact sciences brought with them.

At present a tendency of thought may exist in Germany, akin to the positive philosophy in France and England, which aims at introducing the methods of the natural sciences so as to cover the whole ground of research, and to allow of no other methods. Should it succeed, it will destroy the essential features of the German university system, and with it the ideal of *Wissenschaft* as it has existed in all the leading minds of Germany during the last hundred years.

I intend to come back to this subject later on, and to define more clearly what the German ideal of science —what *Wissenschaft*—is. That which we are occupied with at present is the diffusion of the scientific spirit, in the narrower sense, as it was firmly established in France through the great mathematicians and scientists at the

the studies of classical antiquity"; he maintained that philology, as science, not the barren training of a pedagogic seminary, is the only right thing for future masters. "The good teacher must, even for teaching purposes, have and know, both in quantity and quality, more than he requires for immediate progress; the portion he requires for immediate communication, for practical teaching purposes, must be delivered out of the fulness and the depth of knowledge; it must, even in its circumscribed nature, contain the germs of further mental development. Such depth, such fructifying power, comes only from science" (*Wissenschaft*). See Ribbeck, 'Leben Ritschl's,' vol. ii. p. 277. And as every mode of thought, if clearly felt and active, finds its expression in language, so Ritschl was fond of characterising his scientific method by the word ἀκρίβεια.

beginning of this century, as it is summed up in their works and in the Memoirs of the Institute. What reception did it find in Germany? How has it thriven under the German university system? These are the questions which interest us at present.

12 Reception of Exact Science in Germany.

The general recognition of the purely scientific studies conducted on a large scale by the French Academy of Science, as an integral portion of the German university syllabus, belongs to the beginning of the present century. During the first forty years of the century complaints were continually heard that some of the most important sciences were not worthily represented.[1] The eighteenth

[1] One of the latest instances of such complaint is to be found in J. Liebig's paper "On the state of Chemistry in Austria" ('Annalen der Pharmacie,' 1838, vol. xxv. p. 339). This was followed by the highly interesting pamphlet 'On the state of Chemistry in Prussia' (Braunschweig, 1840) According to the eminent author, chemistry was the science which was the latest to attain a worthy domicile and an independent footing in the great universities of Germany. Mathematical physics had a centre at Konigsberg, physiology had been established as an independent science at Berlin through the appointment of Johannes Muller in 1833, chemistry was still only taught in Prussia in connection with other branches of science, with medicine, with technology, with mineralogy. There were no chemical laboratories to be found in Prussia Men like Rose, Rammelsberg, Mitscherlich, received none or only the scantiest support in their practical courses of chemistry. It is interesting to note how Liebig, whilst pointing to the enormous importance which chemistry possesses from an economic and political point of view by reason of its working great changes and revolutions, industrial and other, insists on the necessity of teaching chemistry scientifically, and not with an immediate practical bias. In this respect he is as much a representative of the scientific spirit in the wider sense as the great men mentioned in the note to p. 171. The following passage (p. 39) may still be read with interest and profit: "I have found among all who frequent this laboratory [Giessen] for technical purposes a prominent inclination to occupy themselves with applied chemistry. They usually follow hesitatingly and with some suspicion my advice to leave alone all this time-absorbing drudgery, and simply to become acquainted with the necessary ways and means of solving purely scientific questions. By following this advice their minds learn easily and quickly how to find the best means; they themselves adapt them to circumstances and modify them; all operations, all analyses, which serve to ascertain a certain state, which must be made in order to find the conditions

century produced in Germany men of great scientific importance; but their position was irregular and uncertain, and they undoubtedly do not wholly or exclusively belong to the history of the university system. Leibniz, Euler, Haller, Werner, Markgraf, Tobias Mayer, Lambert, and Humboldt are all intimately connected with the growth of modern science: their position and sphere of action were in each case different.[1] Leibniz was a courtier, Euler an

for the solution of the problem, have a definite sense; each of them possesses a certain charm which dispels fatigue, and if the question is really answered, then they know the ways and means of attaining similar ends I know many who are now at the head of soda-, vitriol-, sugar-factories, of colour-works and other establishments Without ever having had anything to do with them beforehand, they were in the first half-hour acquainted with the processes, the second already brought a number of appropriate improvements, &c., &c." Similarly Helmholtz in 1862 ('Reden,' vol. i. p. 142): "He who in the cultivation of the sciences aims at immediate practical usefulness, may be pretty sure that he will miss his aim. Science [*Wissenschaft*] can aspire only to a perfect knowledge and a complete understanding of the sway of physical and mental forces. The individual worker must find his reward in the joy over new discoveries, as new victories of mind over matter, in the æsthetical beauty which an orderly display of knowledge affords, &c., &c." How little do our modern colleges of science correspond with this view of *Wissenschaft*!

[1] On Leibniz (1646-1716), see p. 158, Werner (1750-1817), p. 118; and Tobias Mayer (1723-62), p. 158. A. von Humboldt (1769-1859) is well known to English readers. Leonhard Euler (1707-83), a native of Basel, passed the greater part of his life at St Petersburg as a member of the Academy, a portion of it (1741-66) as an Academician at Berlin. He has been termed the father of pure mathematics, inasmuch as he freed mathematical analysis from geometrical conceptions, established the notion of function or mathematical dependence, and did much to make the theory of numbers an independent branch of science. His memoirs are said to number nearly a thousand; his works, if all printed, would fill 60 to 80 quartos (see Hankel, 'Die Entwicklung der Mathematik,' Tubingen, 1884, p. 12). Andreas Sigismund Markgraf (1709-82) was born and lived at Berlin, a member of the Academy On his various chemical researches see Kopp, 'Geschichte der Chemie,' vol. i p 208. Albrecht von Haller (1708-77) was a native of Bern He was, next to Leibniz, perhaps the most encyclopædic mind of modern times, equally celebrated as botanist, physiologist, and poet. He has been termed the father of physiology. Brought up under the celebrated Boerhaave, he accepted a chair at the newly founded University of Gottingen in 1736, and taught there for seventeen years anatomy, botany, medicine, and surgery.

academician, Werner the head of a great mining school, Humboldt a traveller, Markgraf a private gentleman. Haller, indeed, shone as a great light in the University of Gottingen, where he did more than any other to place scientific studies on a level with classical ones, and to create for them a permanent abode within the pale of "alma mater." He founded in 1751, in close connection with the university, the *Göttingen Society*, which from 1753 published the celebrated 'Gottinger Gelehrte Anzeigen.'[1] Tobias Mayer and Lambert[2] can hardly be said to have got much help either from the university, to which the former belonged, or from the Academy, of which the latter was a member; their celebrity rests on works produced by private and unaided effort. Humboldt also depended upon his personal means and upon his connection with the Paris Academy, and only attained late in life, and in the course of the present century, his eminent position as the head and patron of German science. Von Zach and Olbers, who together with Tobias Mayer and Lambert raised German astronomy during the eighteenth century to the level of English and French science, stood outside the university system. Von Zach was indebted to personal connections, and ultimately to Duke Ernest II. of Gotha, for the position which

[1] The 'Gottinger Gelehrte Anzeigen' had existed since 1739.

[2] Joh Heinrich Lambert (1728-77), a very extraordinary man, was a native of Muhlhausen, Alsace, which then belonged to Switzerland. He was received as a member of the Berlin Academy, and associated there with Euler and Lagrange. He is celebrated through his 'Photometry' (1760) and 'Pyrometry' (1779), his equation referring to the orbits of comets, employed by Olbers in his method for calculating them (Weimar, 1797, republished by Encke, 1847), and his prophetic prediction of the proper motion of the sun (in his Cosmological Letters, 1761). This motion was actually calculated by Sir William Herschel in his paper "On the proper Motion of the Sun and Solar System" ('Philos Trans,' 1783).

held as a kind of corresponding centre of European astronomy, and as the leader of a large school of German astronomers of this century.[1] Olbers was a practising physician at Bremen,[2] where he followed astronomical studies as a recreation, making himself eminent by great services to science, among them by his method of calculating the orbit of a comet: as the greatest of his services he counted the fact of having discovered, trained, and appreciated the rising genius of Bessel.[3]

[1] Franz Xaver von Zach (1754-1832) was a native of Pesth. After having served in the Austrian artillery, and taken to astronomy as a favourite study, he spent some time in Paris and London, and became acquainted with Lalande, Laplace, Herschel, Maskelyne, Ramsden, and others. He was engaged by Duke Ernest II of Gotha in 1786 to erect an observatory on the Seeberg near Gotha This was completed in 1791. Here he trained a number of younger astronomers, and was the first to establish and maintain a periodical specially devoted to astronomy. It was first (1798) published under the title 'Geographische Ephemeriden,' then (1800-18) as 'Monatliche Correspondenz zur Beförderung der Erd- und Himmelskunde.' Lalande and Gauss both testified to the usefulness of this international publication, without which Piazzi's discovery (see p. 182, note 1) would probably have been lost. See Wolf, 'Gesch. d Astronomie,' p. 764.

[2] Heinr. Wilh. Mat Olbers (1758-1840) was born near Bremen. He followed astronomy as a private study. He is mainly known by his rediscovery of the first of the smaller planets (see p. 182, note 1), by his theory, once generally accepted, of the origin of the smaller planets through the disruption of a primitive large planet, and by his 'Abhandlung uber die leichteste und bequemste Methode die Bahn eines Cometen aus einigen Beobachtungen zu berechnen' (1797). In this work, by using Lambert's equation, he succeeded in perfecting the methods of Newton and his successors so as actually to calculate the elements of several comets. This method is still in general use (see Wolf, *loc. cit*, p 519).

[3] Friedr. Wilh. Bessel (1784-1846) attracted the attention of Olbers by his mathematical abilities whilst employed as clerk in a shipping office at Bremen. If Tobias Mayer's lunar tables were remunerated and published with English money, Germany repaid the debt by the industry of Bessel, who calculated and reduced the observations made by Bradley (1692-1762, Astronomer Royal from 1742) at Greenwich during the years 1750 to 1761. They had been neglected and remained unpublished till 1798, when Olbers induced Bessel to make them useful to science. This he did by calculating from them some of the most important and fundamental data of astronomy. After many years of labour he brought out his 'Fundamenta Astronomiæ pro A. 1755 deducta ex observationibus viri incomparabilis James

13. Science not yet domiciled at the German universities during the eighteenth century.

The general impression we receive from a perusal of the histories of science and learning in Germany at the close of the eighteenth century is, that the university system had, so far as philosophical and classical studies were concerned, attained almost to the eminence which it has held during this century, but that it had not—with the exception perhaps of Göttingen—received into its pale the modern spirit of exact research, such as it had been developed by the great French Academicians. Eminent students of science lived outside of the universities, belonging wholly or largely to the international Republic which had its centre in Paris, exerting little influence on higher German education through the universities, and hardly any on German literature, which had meanwhile ripened into the age of Classicism. This scattered condition of German science gave it on the one side a character which was foreign to the general tendencies of German thought, since this had come under the excessive influence of the speculative spirit without that wholesome check which exact research has always exerted.[1]

Bradley in specula astronomica Grenovizensi per A. 1750-62 institutis' (1818) By his determination (1838-40) of the parallax of the star 61 Cygni he made the first accurate calculation of the distance of a fixed star, which he computed at 12 billion astronomical miles

[1] It was the age of the *Naturphilosophie*, which, through the influence of Schelling in the south and Hegel in the north of Germany, filled the chairs in the universities, and penetrated into the learned societies. This philosophy of nature had the effect of frequently replacing induction by speculation, the patient work of the calculator, the observer, the experimenter, and the dissector by general theories, such as, applied to literary, historical, and poetical subjects, had acquired a certain importance, and a semblance of veracity and usefulness In France the whole spirit of the Academy of Sciences opposed this form of learning. Cuvier denounced it or regarded it with suspicion, in England it remained unknown, and in Germany itself individual great minds opposed it, or did their work outside of its influence. Such were notably A. von Humboldt and Gauss. Younger men, such as Liebig and Joh. Muller,

On the other side, we find in the wide domain of general literature valuable beginnings and foreshadowings of later scientific thought, as in Georg Forster[1] and in

came temporarily under its influence. As regards its harmful effect on the natural and medical sciences, the popular addresses of Helmholtz and Du Bois-Reymond may be consulted. Its philosophical value will frequently occupy us in later chapters of this work. Its period can be approximately fixed by the publication in 1797 of Schelling's 'Ideen zu einer Philosophie der Natur.' The death of Hegel in 1831, and Humboldt's Berlin lectures during the years 1827 and 1828, may be considered as marking approximately the end of the generation which came under the one-sided influence of the *Naturphilosophie*. We shall have ample occasion later on to notice how many valuable leading ideas connected with this phase of thought were temporarily abandoned and have since come prominently before the scientific world. The year 1830 marked the victory of Cuvier's ideas over those of his great contemporary Geoffroy St-Hilaire in the French Academy, and with it the temporary defeat of the valuable suggestions contained in the writings of Lamarck and Goethe.

[1] Georg Forster (1753-94) was one of those unique men in the history of literature and science who combine the artistic with the scientific spirit, promoting equally the interests of poetry and of exact knowledge by a loving study of Nature, leading to new views of art as well as to deeper conceptions in science. He may be classed with White of Selborne and other naturalists of England among the small number of those who quietly and unostentatiously prepared the healthier forms of Naturalism which permeate the poetical and scientific thought of our century, culminating in the great names of Wordsworth and Goethe, of Humboldt and Darwin, of Wallace and Haeckel. His life presented many interesting and some unhappy episodes; it introduces us into the political aspirations of the early French Revolution, to which he sacrificed himself. It has been written by Moleschott, the naturalist, by Heinrich Konig, the novelist ('G Forster in Haus und Welt,' Leipzig, 1858, 2 vols.), by Klein ('Georg Forster in Mainz'). Fr. Schlegel ('Charakteristiken und Kritiken,' vol. i.), Gervinus (Introduction to the 7th vol. of 'Georg Forster's Werke'), and Hettner ('Literatur des 18ten Jahrhunderts,' vol. iii.) have written appreciative essays on him. A. von Humboldt calls him his master ('Kosmos,' vol. i. p. 345), and Herder (Preface to Georg Forster's translation of 'Sakuntala') prophesies his lasting fame against the opinion of his less appreciative contemporaries. He has a place in the classical literature both of England and Germany through his beautiful description of Captain Cook's second voyage round the world — his father, Joh. Reinhold Forster, having been selected as the naturalist on that voyage (London, 1777, 2 vols. 4to), German edition, 1779. Richard Garnett has said of him: "His account of Cook's voyage is almost the first example of the glowing yet faithful description of natural phenomena which has since made a knowledge of them the common property of the educated world . . . As an author he stands very high; he is almost the first

Goethe;[1] but they could hardly be encouraged and developed sufficiently without that strict training which is acquired through the routine of the class-room, or under the eye of a recognised authority.

14. Scientific periodicals

The want of academic union and organisation, and the scattered situation of the many small centres of learning and culture in Germany, led, however, to the early development of those scientific periodicals which form such a characteristic feature in German literature. They were the medium for the exchange of ideas, and the collecting-ground for researches, in an age when exact science was not systematically taught at the Universities, and when such researches otherwise would have run the risk of being lost in obscurity or oblivion.

At the end of the eighteenth century Germany,

and almost the best of that valuable class of writers who have made science and art familiar by representing them in their essential spirit, unencumbered with technical details" ('Ency. Brit,' vol. ix. p. 419). Forster lived in the period of transition from the thought of the eighteenth century to that of the nineteenth, and a study of his Life, Works, and Correspondence is a very good introduction to nearly all the great problems which then, especially on the Continent, troubled the minds of the greatest men. If he may be accused of want of patriotism, he is certainly to be admired for his freedom from national narrow-mindedness

[1] It has taken nearly a century before the real value of Goethe's scientific ideas has been correctly gauged. His non-academic surroundings, his unscientific style, his antagonism to Newton, his mission as a poet—supposed in those days to be less realistic than we have since become accustomed to consider it—all these circumstances contributed to the result that Goethe's scientific writings were not taken *au sérieux* by the naturalists of his age. Then came a period when men of science began to sift the wheat from the chaff; but even they have only tardily recognised that, more than in special discoveries or suggestions, his greatness lies in that general conception of Nature which was so foreign to his age, and which nevertheless is becoming more and more familiar and necessary to ours See especially Helmholtz's valuable essays on Goethe as naturalist from the years 1853 and 1892 ('Vortrage,' vol. i, and address delivered at the meeting of the Goethe Society at Weimar, 1892), and the remarkable progress of his own views on this subject contained therein. We shall have ample opportunity of reverting to this subject.

though not by its universities, was already an important power in the Republic of exact science which then had its centre in Paris. Just at the beginning of the nineteenth century two events happened which foreboded for the highest branches of the mathematical sciences a revival of the glory which in this department Kepler and Leibniz had already given to their country. These two events are both coupled with the name of Carl Friedrich Gauss. They added greatly to the reputation of the University of Gottingen, with which this remarkable man was connected for half a century.[1] The *first* was the publication of the 'Disquisitiones Arithmeticæ' in Latin in 1801—a work by which Gauss placed himself on a level with the great mathematicians, Euler, Lagrange, and Legendre.[2] The

15. Gauss's mathematical researches.

[1] Carl Friedrich Gauss (1777-1855), a native of Brunswick, called by Laplace the first mathematician of Europe, may be considered as the first and foremost representative of the modern mathematical school, of which we shall have to treat later on. Unlike most of the great mathematicians of the Continent, he was self-taught, and followed in his earliest works quite independent lines of thought, resembling in this the great isolated thinkers of Britain whose ideas take a generation or more to penetrate into the text-books of the school Gauss had the highest opinion of the dignity of pure science, and it almost appears as if, among the moderns, only Newton had come up to his ideal. For him alone he reserves the adjective "summus," and he adopts his synthetic and classical methods of exposition, removing, as has been said, the scaffoldings by the aid of which he had erected his monumental works. Gauss trained few mathematicians; but among the few who penetrated the secret of his ideas are such original thinkers as the Hungarian Bolyai (1775-1856), the geometers Mobius (1790-1868) and Von Staudt (1798-1867), who all mark quite independent lines of research. On Gauss see Sartorius, 'Gauss zum Gedachtniss,' Leipzig, 1856; Hanselmann, 'K. F. Gauss,' Leipzig, 1878; E. Schering, 'C. F. Gauss,' Gottingen, 1887.

[2] It appears that Gauss, to whom the arithmetical discoveries of Fermat and the proofs of Euler, Lagrange, and Legendre remained for a long time unknown (see his Works, edited by Schering, vol. i. p 6; vol. ii. p 444), had independently, in his eighteenth year, as a student at Gottingen, already arrived at a great number of propositions referring to the properties of numbers, and had then also found methods of geometrically constructing the regular polygon of seventeen sides.

second was the invention of a new and shorter method of calculating the orbit of a planet from a limited number of contiguous observations.[1] This method was communi-

The latter was the first addition made after 2000 years to the knowledge of this matter possessed by the ancients. (See 'Disquis. Arithm.,' sec. 365: "Magnopere sane est mirandum, quod, quum jam Euclidis temporibus circuli divisibilitas geometrica in tres et quinque partes nota fuerit, nihil his inventis intervallo 2000 annorum adjectum sit," &c; and his manuscript note to this passage, given by Schering, vol. i. p. 176: "Circulum in 17 partes divisibilem esse geometrice, deteximus 1796, Mart. 30.") It is probably owing to the independent manner in which Gauss approached the subject that he early found the necessity of treating subjects of higher arithmetic (*i.e.*, of the theory of numbers or "discrete magnitudes" as distinguished from algebra, which is the theory of "continuous magnitudes") by an independent method, for which he invented a language and an algorithm. He thus raised this part of mathematics into an independent science, on which the 'Disquisitiones Arithmeticæ' is the first elaborate and systematic treatise. Legendre's 'Traité des nombres' (1799) is a complete thesaurus of all that was at that time known and of what was added by him, but it does not attempt to establish the science on a new basis.

[1] On the 1st January 1801 Piazzi at Palermo had found a movable star of 8th magnitude, RA 57° 47′, ND. 16° 8′, which he announced to Bode at Berlin as a comet on the 24th January; but a few days later he concluded it must be a planet, and named it "Ceres Ferdinandea." No one besides Piazzi could find the star, but several astronomers, Piazzi himself, Olbers at Bremen, and Burckhardt at Paris, tried to calculate the orbit from the observations of the discoverer, which were contained within only 9 degrees. The attempt to do so under the supposition of either a circular or a parabolic or an elliptic orbit failed, and Olbers expressed the fear that with the circular or elliptic elements which had been published in Zach's periodical, it might prove impossible to find the star when it should again become visible Very near the expected time, as late as the beginning of December, Gauss communicated his elements to Von Zach, who published them at once, recommending astronomers to follow Dr Gauss's figures and look 6° to 7° more eastward than the positions of Burckhardt, Piazzi, and Olbers indicated. And actually on the 7th December 1801 Zach himself, and on the 1st January 1802 Olbers, succeeded in finding the star, "like a grain of sand on the sea-shore," very near the positions calculated by Gauss. These results, followed soon by the discovery of other planets by Olbers and Harding, gave a great impetus to the study of astronomy. Gauss's methods were published *in extenso* in the now celebrated 'Theoria motus corporum cœlestium' in 1809. Two problems are herein treated in a novel and complete manner. The first was to calculate by a simple and accurate method from the necessary number of observations the orbit of a planet or comet on the assumption of Newton's law of gravitation, but without any other special conditions.

called to Von Zach in the course of the year 1801, and enabled him and Olbers to rediscover the first of the small planets, Ceres, which Piazzi had observed on the 1st of January 1801 at Palermo, and afterwards lost as it approached the region of the sun's light. Through this Gauss placed himself on a level with the great French astronomers Laplace, Lalande, and others. The new professor of mathematics and director of the observatory of Gottingen was admitted into the august company of the Paris academicians, who then ruled, and since the death of Euler had almost monopolised, the mathematical studies of the world. Although Gauss thus introduced the higher and abstract branches of exact science into the programme of a German university, and established a link between Paris and Germany in mathematics, as Humboldt had done shortly before in the natural sciences, fully a quarter of a century was to elapse before the spirit of exact research, and of the higher mathematics, really began to leaven the German universities. It then at length entered the field as a third and equally important agent by the side of the

16. Scientific spirit enters the universities in the second quarter of the century

This was achieved to perfection, a proof of the usefulness of the method being the fact that Gauss succeeded in finishing in one hour a calculation which had taken Euler three days, and had resulted in his blindness. The second problem arises from the fact that the number of observations is always in excess of the number mathematically necessary, and that, owing to the unavoidable inaccuracies, different sets of observations give slightly different orbits. How are these to be used so as to give the most correct average result? This involves a question in probabilities. As early as 1795 Gauss was in possession of the so-called method of least squares, which occurred to him so naturally that he suspected that Tobias Mayer must have already known about it It also occurred independently to Legendre, who was the first to publish it, in 1806, in his 'Nouvelles méthodes pour la détermination des orbites des comètes.' See Sartorius, 'Gauss zum Gedachtniss,' p. 41 *sqq.*

philosophical and classical spirit. During these twenty-five years Gauss lived and soared in solitary height—a name only to the German student, as Euler had been before him. Probably he was better known to the younger astronomers whom he trained, and the elder ones with whom he corresponded. But astronomy was not then within the pale of the universities. To what extent the character of Gauss's own genius was the cause of this it is difficult to say.[1] He himself had not come under the influence of any great teachers such as Paris then possessed; he was self-taught, and had early imbibed a great admiration for the methods of Euclid, Archimedes, and Newton; he wrote in the classical style fitted for all times, but not for uninitiated beginners.[2] It is certain,

[1] Bjerknes, in his most interesting memoir on Abel, refers frequently to the awe in which Gauss was held by younger mathematicians.

[2] In this Gauss resembled Newton. He was therefore, like Newton, frequently forestalled by others, who published his new methods and ideas in an unfinished and fragmentary form; whereby it is not suggested that these simultaneous discoveries or inventions were not quite independent. Two examples of this may be added to those given above. When Gauss published the 'Disquis. Arith.' in 1801, he left out the last or eighth section, which was to treat of the residues of the higher orders. He had already nearly completed the theory of biquadratic residues In dealing with this subject he had found it necessary to extend the conception of number beyond the limits then in use. If we confine ourselves to integers, the only extension which then existed of the notion of number was in the use of negative numbers. These were counted on a straight line backward, as positive (or ordinary) numbers were counted forward. Gauss conceived the idea of counting numbers laterally from the straight line which represented the ordinary—positive and negative—numbers. He called numbers which were thus located in the plane "complex numbers," as they had to be counted by the use of two units, the ordinary unit 1 and a new unit i. He also showed that this new unit i stood in such relations to the ordinary unit 1 as were algebraically defined by the mysterious imaginary symbol $\sqrt{-1}$. The complete exposition of this new or complex system of counting was not explained by Gauss till the year 1831, when he published the 'Theoria residuorum biquadraticorum.' In the meantime the geometrical representation of imaginary quantities had been devised and published by Argand (1806), but not being employed for such important researches, it had re-

however, that the spirit of exact and specially mathematical research owed its right of domicile within the universities to others who came after him, and to circumstances with which he was hardly connected.

17. Jacobi's mathematical school.

The man to whom Germany owes its first great school of mathematicians was Jacobi. He was self-taught like Gauss; but whilst Gauss followed in the footsteps of Newton and the ancients, Jacobi followed in those of Euler, Lagrange, and Laplace. The style and methods of these mathematicians, being more suited for didactic purposes than the classical style of Euclid, Newton, and Gauss, was probably more congenial to the mind of Jacobi, who from his twenty-first year (1825) developed a great activity as an academic teacher.[1] He was first

mained unknown and unnoticed. See on the history of the subject, Hankel, 'Theorie der complexen Zahlensysteme,' 1867, pp. 71, 82 Gauss, through hiding his researches on this subject so long, lost the claim to the priority of the invention, though not of the effectual use of it. In another instance he allowed others to appropriate the merit of cultivating a large new field which had been familiar to him many years before. It was known all through the first half of the century that Gauss was in possession of valuable discoveries in what he termed the "new transcendent functions" References in the 'Disquisitiones,' § 335, in his correspondence with Schumacher, Bessel, Olbers, and Crelle, had made his friends curious to see the "amplum opus" which he had promised. It appears, however, that, independently of him, Jacobi and Abel (1802-29) following the investigations of Legendre (whose labours began in 1786 and culminated in his great work 'Traité des fonctions elliptiques, &c,' 1825-28, 2 vols. and 3 supplements), succeeded in developing the theory very much on the same lines as Gauss had taken nearly a generation earlier. Eminent mathematicians who, since the publication of Gauss's posthumous papers, have fully investigated the subject, assign to Jacobi and Abel the undisputed priority of publishing, but to Gauss that of discovering, the fundamental properties of the "doubly periodical" functions. Full details will be found in the historical introduction to Enneper's 'Elliptische Functionen,' 2nd ed., Halle, 1890. See also Gauss's Werke, vol. iii. p. 491-496; Dirichlet's Discourse on Jacobi in Jacobi's Werke, vol. i. p. 11; C. A. Bjerknes, 'N. H. Abel,' Paris, 1885; Koenigsberger, 'Zur Geschichte der Theorie der elliptischen Transcendenten,' Leipzig, 1879.

[1] Carl Gustav Jacob Jacobi (born at Potsdam 1804, died at Berlin 1851) was the first great mathe-

at Berlin, then at Konigsberg, these two universities having become through him and Bessel the German teaching centres of the higher mathematics, both pure and applied. They have up to the present day fully maintained this pre-eminent position. They were teaching centres in the sense defined above—not only as regards mathematical knowledge and method, but likewise as regards mathematical research. For this purpose—as in the philological sciences—the lecture-room was not sufficient; there was also wanted a repository for the independent and original contributions of the school. Like the École polytechnique thirty years before in Paris, the Berlin school of mathematicians started with an important periodical. This was known as Crelle's Journal. Together with the Memoirs of the Paris Academy and the Journal de l'École polytechnique, it forms the principal repository for the higher mathematical work of the first half of the century.[1] It was also through

matical teacher of Germany. Of him Lejeune Dirichlet says "It was not his business to communicate what was finished and what had been communicated before; his lectures all treated of subjects which lay outside of the field of the text-books, and covered only those parts of science in which he had himself been creative. With him this meant that they exhibited the greatest variety. His lectures were not remarkable for that kind of clearness which is characteristic of intellectual poverty, but for a clearness of a higher kind He tried primarily to show the leading ideas which underlay any theory, and whilst he removed everything that had an artificial appearance, the solution of problems presented itself so easily to his hearers that they could hope to do something similar . . The success of this unusual method was truly remarkable. If in Germany the knowledge of the methods of analysis is now spread to a degree unknown to former times, if numerous mathematicians extend the science in every direction, this gratifying result is principally owing to Jacobi. Nearly all have been his pupils," &c. (Dirichlet's Discourse in the Academy of Berlin, 1852, Jacobi's Werke, vol. i. p. 21.)

[1] The two mathematicians on whom A. L. Crelle (1780-1855) relied mainly for contributions when he started the 'Journal fur die reine und angewandte Mathematik' in 1826 were Abel and Steiner. For originality of thought they stand quite alone. Both extended

Jacobi, and still more through his contemporary Lejeune Dirichlet (born 1804 at Duren, of French extraction, and trained in Paris under Laplace, Legendre, Fourier,

the field of research which they cultivated by fundamentally new ideas of such breadth that fully half a century was required before they were thoroughly appreciated by mathematicians Abel (a Norwegian by birth) died in 1829 when only twenty-seven years old, having during the four years which embrace his published memoirs extended the limits of algebra and laid the foundations for a more comprehensive treatment of the higher or transcendent functions, or forms of mathematical dependence. Mathematicians before him had tried to solve algebraically equations beyond the fourth degree, but had failed. Abel proved that the problem as then conceived could not be generally solved. Legendre had through his unaided labours, extending over thirty years, established the theory of elliptic integrals as far as was possible on the lines then adopted. Abel—and simultaneously Jacobi—treated the subject from an entirely novel point of view, and by doing so opened out quite a new field of research, the extent and importance of which Abel fully recognised when he presented to the French Academy his memoir of 1826, in which he dealt with functions of which those studied by Legendre and Jacobi were only special cases This memoir, containing Abel's celebrated theorem, which he had already discovered in 1825, and which was published in a brief article in Crelle's Journal in 1829, remained unnoticed, being, as Legendre explained to Jacobi, almost unreadable. See Enneper, 'Elliptische Functionen,' 2nd ed., p. 192; Jacobi's Werke, vol. i. p. 439, &c. Abel has been called the greatest mathematical genius that has yet existed (Oltramare in 'La grande Encyclopédie,' art. "Abel"); his fellow-worker, Jacob Steiner (1796-1863, a Swiss by birth), has been termed the greatest geometrician of modern times. The progress of analysis had thrown into the background purely geometrical researches, although a revival of these had commenced in France with Monge and his followers, and had been further promoted by Poncelet, as well as simultaneously by Mobius and Plucker in Germany. The labours of the two latter remained for a long time unknown and unrecognised. Steiner, who was self-taught, who disliked the calculus, and considered it a disgrace that geometry could not solve her problems by purely geometrical methods, undertook to find the common root and leading principle which connected all the theorems and porisms bequeathed to us by ancient and modern geometry; he brings order into the chaos, and shows how nature with a few elements and the greatest economy succeeds in giving to figures in space their numberless properties. He not only completed that part of geometry which had been treated by the ancients—the geometry of the line, the conic sections or curves of the second order, and the surfaces in space corresponding to them—but he also attacked problems which before him had been solved only by the calculus, and even succeeded in carrying his methods beyond the reach of the calculus of variations, specially invented to deal with geometrical questions. Like Fermat in the theory of numbers,

Poisson, Cauchy), that the great work of Gauss on the theory of numbers, which for twenty years had remained sealed with seven seals, was drawn into current mathematical literature, and became, as Newton's 'Principia' had become a century earlier, an inexhaustible mine of wealth for succeeding generations.

18. Chemical laboratories established in 1826 through Liebig.

About the same time the experimental side of exact research—the use of the chemical balance, through which Lavoisier and his followers had done so much to establish chemistry on a firm and independent basis—received a great impetus by the establishment of the *first chemical laboratories* within the pale of the universities.[1] In this direction the greatest influence probably belongs to the small town of Giessen, where Liebig opened his celebrated laboratory in the year 1826. It became the

Steiner in geometry left to his followers a large number of theorems and problems without proofs which he had solved by his methods; and it was only in quite recent times that the Italian Cremona succeeded in definitely clearing up the whole of this original and valuable bequest. See Hankel, 'Die Elemente der projectivischen Geometrie, chapter i.; Jacob Steiner, Werke, vol. ii. p. 495.

[1] On Liebig's laboratory see Hofmann's Faraday Lecture, p. 8. Chemical laboratories existed for teaching purposes before Liebig's at Giessen. Kopp ('Geschichte der Chemie,' vol. ii. p. 19) mentions one at Altorf, which was founded, 1683, by the council of the city of Nurnberg for academic teaching purposes For the training of the modern school of chemists no man did more than Berzelius, in whose laboratory there were trained Chr. Gmelin, Mitscherlich, H. and G. Rose, Wohler, Magnus, Arfvedson, Nordenskiold, Mosander, and others. Sir William Thomson (Lord Kelvin) in 'Nature,' vol. xxxi. p. 409, mentions the beginnings of laboratory-teaching at Glasgow by Prof. Thomas Thomson in 1828 But what was probably peculiar to Liebig's laboratory was the systematic and methodical training, on a specially devised plan, in qualitative, quantitative, and organic analysis, by which young persons were introduced to a thorough knowledge of chemical properties and manipulations. The guides, text-books, and tables for analytic work of Will, Fresenius, and others were elaborated to meet the requirements of such methodical teaching. Almost simultaneously with Liebig at Giessen, Purkinje at Breslau laid the foundation for the first physiological laboratory. See Du Bois-Reymond, 'Reden,' vol. ii. p 367

training-school for the greater part of the eminent chemists outside of Paris, and the model for similar establishments, and extended its influence over the world—into England, Scotland, and America. It also did more than any other institution of that kind for the development of ready and accurate methods of analysis, such as are now used in the remotest regions. But it was significant for German chemistry, and for the cosmopolitan character of German science generally, that this brilliant development of experimental research was stimulated from two independent centres; that German chemists as little as German mathematicians attached themselves in a one-sided manner to the Paris school.

19. Cosmopolitan character of German science.

In mathematical science the classical style of Gauss, transmitted from the ancients through Newton, combined with the analytical or modern French style of Jacobi and Dirichlet to give to German research its character of universality. In a similar manner, when chemistry again found a domicile in Germany and became an integral portion of the university programme, it had been trained in two different schools. For there lived at that time in Sweden the eminent authority Berzelius,[1] who divides with Gay-Lussac the glory of being

[1] J Jacob Berzelius (a Swede, 1779-1848), one of the most eminent and industrious of chemists, had a great influence on the development of modern chemistry by the number as well as by the accuracy of his experimental determinations, by his invention of methods and apparatus for analysis, and by his extensive proofs of several of the most important theories. The latter directed the labours and governed the opinions of many—especially German—investigators It was through him mainly that Richter's chemical equivalents and Dalton's atomic theory were extensively verified and applied to all parts of the science, to organic and mineralogical chemistry. He also elaborated, in close connection with Davy's electrical discoveries, his celebrated electrochemical theory, which up to the year 1840 was very generally accepted by chemists; and he assisted through his repeated [illegible]

the master of the great German chemists of the middle of the century. Mitscherlich at Berlin and Wohler at Göttingen belonged to the school of the former, whereas Liebig had the good fortune to be introduced through Humboldt into Gay-Lussac's laboratory at Paris as the first pupil.[1]

and criticisms in breaking down the older oxygen theory of acids in favour of Davy's more general views, based upon his recognition of chlorine and iodine as elementary bodies. His handbook of Chemistry, as well as his 'Jahresbericht' (from 1820), probably did more than any other publications for the diffusion of accurate chemical information.

[1] Liebig has himself, in an autobiographical memoir published posthumously, so fully described the merits of the two schools, and at the same time given such a vivid picture of the truly scientific spirit which animated German universities at that time, that I am tempted to give here some extracts. Of his studies in Paris he says: "What influenced me most in the French lectures was their inner truthfulness and the careful omission of all mere semblance of explanations: it was a complete contrast to the German lectures, in which, through a preponderance of the deductive process, the scientific doctrine had quite lost its rigid coherence. . . . I returned to Germany (1824), where, through the school of Berzelius, . . . a great reform had already begun in inorganic chemistry. . . . I always remember with pleasure the twenty-eight years which I passed at Giessen . it was, as it were, a higher providence which led me to the small university. At a large university, or in a larger town, my powers would have been broken up and frittered away, and the attainment of the aim which I had in view would have been much more difficult, if not impossible; but at Giessen all were concentrated in the work, and this was a passionate enjoyment." "The necessity of an institute where the pupil could instruct himself in the chemical art, by which I understand familiarity with chemical operations of analysis and adroitness in the use of apparatus, was then in the air, and so it came about that on the opening of my laboratory . . . pupils came to me from all sides. . . . The greatest difficulty presented itself, as the numbers increased, in the practical teaching itself. In order to teach many at once, an ordered plan was required and a progressive way of working, which had to be thought out and tried . . . A very short time had sufficed for the celebrated pupils of the Swedish master to give to mineral analysis . . . an admirable degree of perfection. . . . Physical chemistry . . . had through the discoveries of Gay-Lussac and Humboldt, . . . and of Mitscherlich, . . . gained a solid foundation, and in the chemical proportions the edifice appeared to have received its coping-stone. . . . No organic chemistry . . . then existed; Thénard and Gay-Lussac, Berzelius, Prout, Dobereiner, had indeed laid the foundation of organic analysis; but even the great investigations of Chevreul on the fatty bodies received for many years only scant attention. Inorganic chemistry still absorbed too many, and indeed the best, forces.

Twenty years after Gauss's great mathematical achievements, two new discoveries announced to the scientific world that Germany had again taken a foremost position in chemistry. These were Mitscherlich's discovery of isomorphism in 1819,[1] and Wohler's preparation of an organic compound from inorganic materials in 1828.[2]

20. Liebig's organic analysis.

In 1830 Liebig succeeded in finally establishing that simple and accurate method of organic analysis known by his name. Organic chemistry, in its modern sense,

The direction I had received in Paris was a different one. . . . I saw very soon that all progress in organic chemistry depended on its simplification. . . . The first years of my residence at Giessen were almost exclusively devoted to the improvement of organic analysis, and with the first successes there began at the small university an activity such as the world had not yet seen. . . . A kindly fate had brought together in Giessen the most talented youths from all countries of Europe. . . . Every one was obliged to find his own way for himself. . . . We worked from dawn to the fall of night: there were no recreations and pleasures at Giessen. The only complaints were those of the attendant, who in the evenings, when he had to clean, could not get the workers to leave the laboratory." See 'Deutsche Rundschau,' vol. lxvi. pp. 30-39.

[1] Eilhard Mitscherlich (1794-1863), a pupil of Berzelius, discovered in 1819 that in compound bodies which crystallise in definite forms certain elements can be replaced by others in the proportion of their chemical equivalence without changing the form of crystallisation. Such elements are termed "isomorphous." Berzelius declared this to be the most important discovery that had been made since the theory of chemical proportions had been established.

[2] This synthesis was the preparation of urea, a highly organic substance, out of the compounds of cyanogen, with the examination of which he and Liebig were then occupied. "It was the first example of the fact that an organic substance could, by chemical methods alone, be produced out of inorganic materials; this discovery destroyed the difference which was then considered to exist between organic and inorganic bodies—*viz.*, that the former could only be formed under the influence of vegetable or animal vital forces, whereas the latter could be artificially produced" (Kopp, 'Geschichte der Chemie,' vol. i. p. 442). It must here be remarked that this statement is only correct if the substances, cyanic acid and ammonia, out of which Wohler produced urea, are considered to be inorganic; inasmuch as neither of them had then been produced otherwise than out of organic substances, the popular notion on Wohler's important discovery requires this correction. See Kopp, 'Gesch. der Wissenschaften in Deutschland,' vol. x. p. 546.

may be said to date from these and other simultaneous labours of Liebig and Wohler.[1] But although the pure sciences, mathematics, physics, and chemistry, advanced on new lines in the hands of German students, and although theoretical investigations have always been favourite pursuits of theirs, as we shall have ample opportunity to note in the course of our further survey, the greatest contribution to the progress of science, and the most brilliant performances of the exact spirit of research which emanated from Germany during the first half of this century, lay in a different direction. And it is hard to believe that the conditions favourable to this peculiar growth could have been found anywhere else than in the German universities. The many elements of thought which meet on that ground, the equal dignity

[1] The joint labours of Liebig (1803-73) and Wohler (1800-82), which have become of such importance to science, form one of the most interesting instances of scientific co-operation between two men pursuing different lines of thought and trained in different schools. See the preface to Hofmann's edition of Liebig and Wohler's Correspondence. In Liebig's autobiographical sketch, quoted above, he thus enlarges on his relations to Wohler: "It was my good fortune that, from the beginning of my career at Giessen, similar inclinations and endeavours secured me a friend, with whom, after so many years, I am still (between 1860 and 1870) connected by ties of the warmest affection. Whereas in me the tendency predominated to look for the likenesses of substances and their combinations, he possessed an incomparable talent for seeing their differences; acuteness of observation was joined in him to an artistic aptitude and to a genius for finding new ways and means of analysis such as few men possess. The perfection of our joint researches into uric acid and the oil of bitter almonds has been frequently praised; this is his work. I cannot sufficiently estimate the advantage which both my own and our joint aims derived from my union with Wohler; for in them were combined the peculiarities of two schools, and the good which each had, attained its value through co-operation. Without grudge or jealousy we pursued our way hand in hand; if one required help, the other was ready. An idea can be formed of this mutual relation when I mention that many of the smaller productions which bear our names belong to one alone, they were charming little presents which one gave the other" (p. 39).

which there belongs to pure and to applied science, the continual contest which exists there between metaphysical and exact reasoning, and the general ebb and flow of rival currents of ideas, all seem to have been necessary to raise to the rank of an exact science those researches which deal with the phenomena of *life* and *consciousness* in their normal and abnormal forms of existence. In the hands of German students[1] chemistry and physics, botany and zoology, comparative anatomy and morphology, pathology, psychology, and metaphysics, have laboured from different and unconnected beginnings to produce that central science which attacks the great problem of organic life, of individuation, and which studies the immediate conditions of consciousness. *Physiology*, or to use its more comprehensive name, *Biology*,[2] may be

21. Biology a German science.

[1] The two greatest discoveries in physiology belong to England These are Harvey's discovery of the circulation of the blood in the seventeenth century, and Charles Bell's discovery of the difference of sensory and motor nerves in the early part of this century. The two men, however, who have done most to establish physiology as an independent science, whose systematic works have done most for the student of physiology, are probably Haller (see *supra*, p. 176), whose 'Elementa' cast into the shade all older handbooks, and Johannes Muller (1801-58), whose 'Handbuch' (1833-40) was translated into French and English. See Du Bois-Reymond, 'Reden,' &c , vol ii pp 143, &c., 195, 360, who also points out how in other sciences, like mathematics, physics, chemistry, Germans made use almost exclusively of translations of French and English text-books and handbooks, whereas in physiology they furnished for a long period the systematic treatises for the whole world (vol. ii. p 196) Physiology has therefore with some right been termed a German science (see Helmholtz, 'Vortrage,' &c , vol. i. pp 339, 362; Du Bois-Reymond, 'Reden,' vol. ii. p. 265) Compare also what Huxley says, 'Critiques and Addresses,' pp. 221, 303. On the connection of physiology with all other sciences see likewise Helmholtz, *loc cit.*; Du Bois-Reymond, vol. ii. p. 341; Huxley, 'Lay Sermons,' &c., p 75; 'Science and Culture,' p 52: "A thorough study of human physiology is, in itself, an education broader and more comprehensive than much that passes under that name. There is no side of the intellect which it does not call into play, no region of human knowledge into which either its roots or its branches do not extend," &c.

[2] The word "biology" seems to have been first used by G. R.

said to be a German science as chemistry has been named a French science. I have already referred to the great Haller in the last century, who may be called the father of physiology; to Blumenbach, the comparative anatomist, and to Liebig and Wohler, who first among chemists succeeded in producing an organic compound by the processes of inorganic chemistry. I have now to add two names, which together mark a great revolution in our ideas of the structure of organisms, and link together the two sciences which had treated separately of the animal and vegetable worlds. About the year 1838 Mathias Schleiden[1] propounded his cellular theory con-

22. Cellular theory of Schleiden

Treviranus (1776-1837), a learned physician of Bremen, who began to write his 'Biologie oder Philosophie der lebenden Natur' in 1796 and to publish it in 1802 (6 vols., 1802-22). Lamarck used the word in his 'Hydrogéologie,' 1801. They, as well as Bichat about the same time, independently "conceived the notion of uniting the sciences which deal with living matter into one whole, and of dealing with them as one discipline" (Huxley, on the study of Biology, 1876, in 'American Addresses,' p 136, &c.) The term, though of German origin, has not found favour in that country, and after having been used officially in France and England, makes its appearance in Germany only since the great works of the modern English school, headed by Darwin, have gained so much influence in Germany In the meantime the biological sciences had been extensively represented at the German universities by chairs of physiology, zoology, botany, &c. According to Huxley, biology has been "substituted for the old confusing name of natural history," and "denotes the whole of the sciences which deal with living things, whether they be animals or whether they be plants" (*loc. cit.*, p. 138) It can be divided into three branches —(1) Morphology, which comprises the sciences of anatomy, development, and classification, (2) the science of the distribution of living beings, present and past; and (3) physiology, which deals with the functions and actions of living beings, and tries to "deduce the facts of morphology and of distribution from the laws of the molecular forces of matter" (Huxley, 'Lay Sermons,' &c, p 83, 1864) To these three Huxley adds ('Ency. Brit.,' art. "Biology") the infant science of "ætiology," which "has for its object the ascertainment of the causes of the facts of biology and the explanation of biological phenomena, by showing that they constitute particular cases of general physical laws" (p. 688).

[1] Mathias Jacob Schleiden (1804-81), for some time Professor of Botany at Jena, was a man of peculiar ability and disposition, combining a philosophical mind with exact knowledge and a general literary taste, not frequently

cerning the structure and growth of plants. About the same time Theodor Schwann[1] extended this theory to animal organisms. A variety of circumstances combined to make the announcement of the *cellular theory*, which will always be associated with those two names, an epoch in the history of scientific, indeed of general, thought. and Schwann

The historian of botany, Julius Sachs, describes the publication of Schleiden's great work as a burst of daylight,[2] and Du Bois-Reymond says: "In order to measure the magical progress which it marks, one must have witnessed the rise of the cellular theory, when it suddenly spread daylight in the darkness of the hidden structure

to be found among men of pure science in Germany. Opposed to the idealistic philosophy as a follower of Fries, and on the other side to the dry systematisation of the Linnæan school, he was the man at once to broaden the scientific view and to create a popular interest in the "life of the plant"-world The titles of his two best known works are characteristic, 'Die Botanik als inductive Wissenschaft' (1842-45), and his short-lived periodical (filled with the labours of his equally important co-editor, Nageli), 'Zeitschrift fur wissenschaftliche Botanik.'

[1] Through the friendship of Schleiden and Schwann (1810-82, a pupil of Johannes Muller and professor at Louvain), two independent courses of research and scientific thought were brought together. Schleiden placed the "cell" —a term used before him by Hooke, Malpighi, Grew, Wolff, Brown, and Mirbel—in the forefront of his description as the element of form and as the origin of life, or—as we now express it—as the morphological and embryological unit, in the plant. A similar series of great names, beginning with Bichat and leading up to Johannes Muller, marks the studies of animal tissues. Schwann, struck with the analogy of Schleiden's nucleated cells and similar structures which he had observed in the notochord, conceived and verified on a large scale the idea "that a common principle of development exists for the most different elemental parts of the organism, and that the formation of cells is this principle." This is the beginning of the cellular theory, which produced at once a reconstruction of the whole of "general anatomy" by Jacob Henle (1809-85), and subsequently the "cellular pathology" of Rudolph Virchow. As the latter has himself said, he aims at the establishment of a general *biological* principle, and thus the discovery of Schleiden and Schwann is characterised as the transition from the "historical" to the "biological" study of animated nature.

[2] See Julius Sachs, 'Geschichte der Botanik vom 16 Jahrh. bis 1860,' p. 203, and in many other passages.

of animals and plants, where the rays of comparative anatomy and embryology could not reach."[1] This bold generalisation, which had been prepared by a long series of botanical and morphological researches in and out of Germany, met alternately with applause and criticism; it gave rise to a long controversy, and was the starting-point of a whole line of important discoveries.[2] It secured for Germany a long period of supremacy in physiological science. This supremacy was more than maintained by a great volume of minute investigations, which emanated from the schools, and centred in the names, of E. H. Weber[3]

23 Ernst Heinrich Weber

[1] Du Bois-Reymond, 'Reden,' vol. ii. p. 541, &c.

[2] "Whatever cavillers may say, it is certain that histology before 1838, and histology since then, are two different sciences—in scope, in purpose, and in dignity—and the eminent men to whom we allude may safely answer all detraction by a proud *Circumspice*"—Huxley in his valuable paper on "The Cell Theory" in the 'British and Foreign Medical Chirurgical Review,' 1853, vol. xii. p. 290.

[3] The three brothers Weber (Ernst Heinrich, 1795-1878; Wilhelm, 1804-91; and Eduard, 1806-71) may be looked upon as early representatives of the best form of German research on the lines now recognised as the true and fruitful ones in natural science. Born in an age when other great and more widely known reformers—such as Liebig, Schonlein, and Joh Muller—freed themselves with difficulty from the prevailing metaphysical systems, they seem to have at once seized the true spirit of exact research without relinquishing the broader philosophical and encyclopædic view of the sciences which they cultivated. Living far into an age when the utilitarian spirit became equally seductive in an opposite direction, they preserved pure and undefiled within themselves the German ideal of *Wissenschaft* as a pursuit carried on for its own intrinsic value, not for any immediate practical object. Their position, especially that of the two elder brothers, is in this respect unique, and may be studied independently of the scientific ideas which they represented, and which will occupy us later on as a chapter in the history of thought characteristic of the German mind and the best type of the university studies. In three works of classical value—'Die Wellenlehre auf Experimenten begrundet' (E. H. and W. Weber), 1825; 'Die Mechanik der menschlichen Gehwerkzeuge' (W. and E. Weber), 1836, 'Elektrodynamische Maasbestimmungen' (W. Weber), 1846 onward—and in a great number of special investigations, the method of exact measurement was applied to physical, physiological, and even mental phenomena, and the foundation laid for a mechanical description and mathematical calculation. The later generalisations, known as Wilhelm Weber's law of electro-dynamics and E. H. Weber's law of psycho-physics, have given rise to

and Johannes Müller. The school of the latter especially has the merit of having introduced over the whole field of physiological phenomena exact methods of inquiry, of having established physiological laboratories all over Germany similar to Liebig's chemical laboratory at Giessen, and of having effectually chased away the vague notions of the older metaphysical school, and diffused the true scientific spirit. It boasts of having filled the chairs of medicine, physiology, and anatomy at the German universities with a long list of eminent teachers who have spread this true scientific spirit in every branch of the medical sciences,[1] which it has in consequence drawn into

and Johannes Muller.

long controversies and fruitful theories Their joint labours cover fully half a century. See for a sympathetic picture of the position which the three brothers Weber held in the learned world the biography of Fechner by Kuntze, 1892, p. 243: "They were among the first to raise the study of Nature among Germans to the eminence occupied by the philosophers and discoveries of the Latin races."

[1] The medical sciences, represented by the medical faculty, but also by those biological sciences which, like botany, zoology, anthropology, &c, belong to the philosophical faculty, now furnish the largest number of students to the German universities. In the beginning of the century the theological faculty, which then included the greater part of those who prepared themselves for higher teaching, stood at the head as regards numbers. Under the influence of the philologico-historical movement, which grew and culminated in the course of this century, and the rising tide of the exact sciences, the philosophical faculty for a time gained and maintained the upper hand. Biological — including medical — studies now command the greatest attention. In his statistical report (contained in Lexis, 'Die deutschen Universitaten,' Berlin, 1893) Prof. Conrad gives an interesting table of the changing numerical proportion in the different faculties (vol. i. p. 125, &c.) Prof. Billroth in his admirable treatise, 'Ueber das Lehren und Lernen der medicinischen Wissenschaften,' Vienna, 1876, deals with this subject at all the German universities, including the Austrian. As Vienna is such an important centre of medical studies, the proportion of those students who cultivate biological studies would probably be still greater if we were to include the Austrian universities. I suppose the figure would be about 40 per cent of the whole To Billroth's treatise I may also refer as confirming in relation to these more modern branches what I said above of the culture of *Wissenschaft*. See p. 279 and the whole section on the relation of the biological sciences to the university, pp. 411-446. It is

the circle of the exact or mechanical sciences But not only in its far-reaching applications to medical knowledge and practice has the movement which centred in Weber and Muller shown its strength and importance; it has also, from the commencement, extended its influence in another direction. To it belongs pre-eminently the cultivation of that borderland which connects the natural and the mental sciences. Muller[1] himself began his career by a study of the mechanism of the perceptions of the senses. He affirmed the law of *specific energies*,

24. Psycho-physics

interesting to note that Prof Billroth does not employ the word biological, but uses the untranslatable compound *naturwissenschaftlich-medicinisch*

[1] Johannes Muller (1801-58) has been termed the Haller of the nineteenth century, the Cuvier of Germany. A very good account of his work, which forms an important chapter in the history of German biology, is contained in Du Bois-Reymond's 'Gedachtnissrede auf Joh. Muller' (1858), reprinted with extensive notes in his 'Reden,' vol ii. pp 143-334. Muller is there considered as the last representative of a dynasty of philosophers who embraced the whole domain of "biology," which since has become divided into various sciences, notably the morphological and the physiological branches He thus stands out as the master of some of the greatest modern representatives of natural and medical science, such as Schwann and Henle in anatomy, Brucke, Du Bois-Reymond, and Helmholtz in physiology, Virchow in pathological anatomy He together with Lucas Schonlein (1793-1864) may be considered as the founder of the modern Berlin school of medicine, contemporaneous with which is the modern Austrian school, with the names of Purkinje, Skoda, Oppolzer, and Rokitansky. An excellent characterisation of the different positions and influences, of the cross-currents of thought, of the original homes and of the wanderings of the scientific spirit through the many German-speaking countries and the extensive network of German universities, will be found in Billroth, *loc. cit*, pp. 307-366. If we imagine a similar life as existing all through the century in other domains of thought—in philosophy, theology, philology, mathematics, chemistry, law, and the science of history—we get a faint idea of the work of the German universities. In Lexis, 'Die deutschen Universitaten,' an attempt has been made to give such a picture. The picture, however, suffers by the exclusion of the Austrian universities, and these—notably in the medical world—hold such a very high position that the record of the united work is somewhat incomplete. The sciences are also in this record cut up into many branches, whereas in the earlier part of the century many of these were united and represented by one great name. Such a name was Johannes Muller in biology.

which declares that the differences of the sensations of light and colour, of sound, of touch, &c., do not depend upon the mode of irritation, nor even upon the different structure of the specific nerves, but upon the nature of the central sense organ. In the school of Müller the phenomena of voltaic electricity, which had been so seductive and misleading to an earlier school of physiologists not experienced in the methods of exact research, were again subjected to scientific investigation, and led to the brilliant researches with which the name of Du Bois-Reymond is so intimately connected. He is as ready as Helmholtz, who in his two great works on physiological optics and musical acoustics has founded new branches of science,[1] to acknowledge the leadership of Johannes

[1] Helmholtz (1821-95), equally celebrated as physiologist and mathematical philosopher, was educated under the influence of Johannes Müller on the one side, of Jacobi and the Königsberg school of mathematicians (Bessel and Neumann) on the other. If we add to this that he also made a profound study of those far-reaching speculations which originated in the philosophy of Kant, we realise how rare is the combination of ability and knowledge which he has brought to bear on the discussion of the most advanced problems in physics, biology, and psychology In the sequel I shall have to refer so frequently to his writings that I confine myself here to giving the date of his principal, his epoch-making publications. 1847. 'Ueber die Erhaltung der Kraft'; 1858. 'Ueber die Integrale der hydrodynamischen Gleichungen, welche der Wirbelbewegung entsprechen'—both reprinted in 'Wissenschaftliche Abhandlungen,' Leipzig, 1882 and 1883, 2 vols. These two Memoirs may be considered as corner-stones of two of the most important modern theories in physical science, the "conservation of energy" and the "theory of vortex motion" In both, the name of Helmholtz is intimately allied with that of William Thomson (Lord Kelvin) Equally important and more comprehensive have been his researches in the physiology and psychology of sense-perceptions in his 'Physiologische Optik,' Leipzig, 1867; 'Lehre von den Tonempfindungen,' Braunschweig, 1863.

Helmholtz has also contributed largely to the discussion of two very important branches of modern speculation—first, the theoretical views on the nature of electrical phenomena expressed by the opposite conceptions of Wilhelm Weber in Germany and Faraday in England; second, the origin of geometrical axioms, especially the axiom referring to parallel lines. A great interest in this subject had been

Muller. And out of the circle of which E. H. Weber was the centre, has emanated that work of Fechner, 'Elements of Psycho-physics,' which marks an epoch in psychology: it is indeed mainly occupied with the exposition and application of what is termed Weber's law of sensation.[1] In the course of the second quarter of the century, the names of Gauss and Jacobi in mathematics, of Liebig and Wohler in chemistry, of Schleiden and Schwann in the science of life, of Muller and Weber in physiology, raised German science to the level previously reached by the French Academicians, by Laplace and Lagrange, by Lavoisier and Berthollet, by Cuvier and St-Hilaire, by Vicq-d'Azyr and Bichat. During

created by the posthumous publication of Riemann's celebrated Memoir, 'Ueber die Hypothesen welche der Geometrie zu Grunde liegen,' Gottingen, 1865. Helmholtz's invention of the ophthalmoscope in 1851 marks an epoch in ophthalmology

[1] Gustav Theodor Fechner (1806-87), professor at the University of Leipsic, was an extraordinary man. The wide range of his interests and his great personal influence are well described in his biography by Dr Kuntze, 'G. T. Fechner, Ein deutsches Gelehrtenleben,' Leipzig, 1892. Together with Lotze he may be said to have brought about the reform of German speculative philosophy, and in relation to this he will occupy our attention largely in a later portion of this book. He belonged to the circle of which E. H. Weber was the centre, and has taken an important place in the history of philosophy and science by his now celebrated work, 'Elemente der Psychophysik,' 2 vols., Leipzig, 1860; 2nd ed, 1890. The object of this work is to establish "an exact doctrine of the relations of body and mind," the principal task being "to fix the measure of psychical quantities." He says in the preface: "The empirical law which forms the principal foundation, was laid down long ago by different students in different branches, and was expressed with comparative generality mainly by E H. Weber, whom I would call the father of psycho-physics" (Preface, p. v). In early life Fechner did much, by his translations of Biot's 'Physics' and Thénard's 'Chemistry,' as well as by his own experimental works, to introduce the French scientific spirit into German research. His psycho-physical labours have been continued by Prof. Wundt; his importance as marking a turning-point in German philosophy is brought out in Paulsen's 'Einleitung in die Philosophie,' Berlin, 1890. See especially Preface, p viii, and p. 318, where Fechner is placed before Lotze.

the second half of the century, the influence of French thought on German science has been less marked, partly owing to the independent course which the latter, since the age of Johannes Muller, has struck out for herself in the biological sciences, partly through the more intimate intercourse which has set in between English and German thought. The three great scientific ideas which the second half of the century has been establishing—the law of the conservation of energy, Darwin's theory of descent, and Faraday's novel conception of electrical phenomena—have been elaborated mainly by the co-operation of English and German research, though it must be admitted that at least one of these developments dates back to the beginnings laid by French science,[1] whilst the views of Faraday are subversive of some of the fundamental notions to which the works of the great French mathematicians had given very general currency. Before we can enter more fully on a review of these more modern ideas, I must, however, give a picture of the state of scientific thought in England during the first half of the century. This will be our subject in the last portion of the present section.

[1] Darwin's theory of descent has its forerunners in Lamarck and St-Hilaire, whose merits in this respect are supposed to have been overlooked owing to the overwhelming authority of Cuvier. See Huxley, "Origin of Species" in 'Lay Sermons,' 1891, p. 252; "Evolution in Biology" in 'Science and Culture,' 1888, pp. 296, 313 But whilst it is true that Lamarck and St-Hilaire entertained doubts as to the fixity of species, the explanation of the particular manner in which the change of species takes place is entirely due to Darwin, and without this further step speculations as to the origin of species would have remained for a long time in the vague Lamarck's speculations were of no real use to Darwin, and had besides been anticipated by Erasmus Darwin. On the other hand, the researches of Sadi Carnot were of great value in the hands of Joule, Thomson, and Helmholtz, who may be regarded as the founders of the doctrine of the conservation of energy.

25 Spirit of exact research and *Wissenschaft*

But it is my object at present not so much to dwell upon specific ideas or doctrines as on the growth, the diffusion, and the general character of scientific thought, as this has been established by the separate contributions of the three nations in the course of the first half of our century. I therefore cannot leave the subject of German science without still more precisely noting the peculiar character which scientific thought has assumed under the influence of the German university system. As we saw before, when the spirit of exact research, mainly through the influence of the great French mathematicians and physicists, became diffused in Germany, and entered the pale of the German universities, it was met there by that peculiar ideal of learning which the German language terms *Wissenschaft*. This encounter did not everywhere produce a favourable reception for the new school, but in the end it led, like every controversy, to a firmer establishment of the true principles of research. The life of the German universities had in the earlier centuries begun with classical studies; it had been reformed under the influence of the theological and juridical requirements of the Protestant Governments; and ultimately it had been entirely renewed under the influence of the classical and philosophical studies centred in the fourth or philosophical faculty. These classical and philosophical studies combined to create the ideal of *Wissenschaft*, or science, in the broadest sense of the word. This ideal formed the central conception in the new scheme of a higher and general education of the nation; it accompanied the great revival in art, poetry, and literature. In the

philosophy of Kant and Fichte, the republican notions which led the political movements in America and France had been reduced to a system and theoretically proved; the discipline of a classical education was the school in which leaders and youths were trained who marched into the war against the great oppressor. This ideal of *Wissenschaft* had thus acquired a practical meaning, an ethical—not to say a religious—significance, it was allied to the religious revival preached by Schleiermacher and a section of the Romantic school. Of its value as a principle for guiding research and learning it had given proof in that great circle of studies which, since the time of F. A. Wolf and Wilhelm von Humboldt, was comprised under the name of *Philology*. Under its influence new universities were being founded and academies remodelled.

Now, it is the peculiarity of all philosophical and historical studies that they deal with one great subject, which cannot easily be divided into a number of independent parts capable of separate treatment; since their interest attaches mainly to the fact that they explore the workings and manifestations of the human mind in the past and in the present. These studies are therefore forced to keep always in the foreground the idea of a great unity of action and purpose, to aim at completeness of view, and to refer all special researches to general principles and standards. The encyclopædic view, in fact, is forced upon all philosophical and historical sciences. Almost without exception the great masters and teachers who lived in the beginning of this century adhered to this view, and however great in special and

26 Encyclopædic view necessary in philosophy and history.

detailed research, measured the importance of their results according to the light which they were able to throw upon the questions referring to the whole subject and its combined life and unity.

It was also natural, seeing that this comprehensive or philosophical treatment led to such great results in the historical sciences, that an attempt should have been made to deal with the phenomena of Nature by a similar conception. It was not a new or a far-fetched suggestion to regard Nature as the playground of a hidden intelligence, of an unconscious mind, just as history, language, and thought were viewed as the manifestations of the conscious human mind. After this the further conception was not remote that both the mind of Nature and the mind of Man are only two different sides of the universal or absolute Mind. The philosophy of Schelling was the first attempt to put this idea into an applicable form, the system of Hegel the first confident elaboration of it in its various ramifications and applications. At the time when the mathematical and physical sciences were leading the way in France, and gradually forcing their way into Germany, most of the universities in the latter country had one or more representatives of that new and apparently promising school which termed itself the "Philosophy of Nature." The trammels of this school had to be shaken off by those who, as they became gradually convinced of its barrenness in actual results, took up the cause of the exact or mathematical sciences now that they had been cultivated by many isolated labourers in Germany and in England, and had been

27 Philosophy of Nature

for the first time connected into a great organisation by the French Academy of Sciences.

28 Conflict between the scientific and the philosophical views.

The opposition in which the new school of exact and detailed research stood to the representatives of the broad philosophical view gave rise to a great many currents of thought, for neither the former nor the latter presented a united front. Among those who advocated the exact methods of research there was a section which clung more exclusively to the empirical side, and cultivated the descriptive and experimental sciences; whereas others, whom we may call the French school of science, developed the mathematical methods, not without a certain ill-disguised contempt for pure empiricism.[1] On the side of classical and philosophical studies there was a section which cultivated the historical[2] in contradis-

[1] On the relations of mathematical and experimental physics, and the different opinions which existed during the first half of the century, see Helmholtz's popular addresses in many places, but especially the discourse on Gustav Magnus (1802-70), who may be regarded as a representative of the experimental school in Germany In the opinion of this school, which cultivated the borderland of physics and chemistry, of organic and inorganic phenomena, or investigated the less known phenomena of frictional electricity (Riess) or the complicated phenomena of meteorology (Dove), a danger existed that mathematical theories and elaborate calculations might lead to an estrangement from nature and observation, similar to that which speculative philosophy had created before Helmholtz himself was met by this sentiment when he published his great memoir, 'Ueber die Erhaltung der Kraft,' in 1847; Poggendorf's physical periodical would not receive it, and Jacobi, the mathematician, was the only one who showed any interest in it See Helmholtz, 'Wissenschaftliche Abhandlungen,' vol. i. p. 73; 'Reden,' vol. ii. p. 46.

[2] As the philosophy of Schelling promoted a study of nature, and in doing so prepared its own downfall, so the philosophy of Hegel led to a study of history, and thus to the proof of the insufficiency of its own generalisations. Many valuable beginnings of historical research emanated also from the Romantic school of literature. In all these instances philosophical interests led beyond the abstract logical and metaphysical treatment into the broad and fertile plains of actual life, be it that of nature or of art or of history. But the true methods of research in

tinction to the philosophical view, and another which elaborated what it termed exclusively the critical methods,[1] not without a certain suspicion regarding those who showed a desire to roam into outlying fields which did not permit of equally strict discipline and treatment. So far as this refers to the purely historical sciences, I shall revert to the subject when I come to treat of the principles which underlie and guide this line of studies. At present I am concerned with the growth and diffusion of the exact scientific spirit and its methods.

29 Alexander von Humboldt

No one did more to spread the ideas and methods of French science in Germany than Alexander von Humboldt. He himself had done original scientific work[2] be-

these extensive fields were afterwards found not so much in philosophical canons as in a love of detail and observation, and in the exercise of an unbiassed criticism of facts and records For the relations of philosophy to history in respect of this, see Wegele, 'Geschichte der deutschen Historiographie,' Munchen, 1885, 5th book, p. 975, &c. Equally important are—Gervinus, 'Grundzuge der Historik,' Leipzig, 1837; the 'Nekrolog auf Schlosser,' Leipzig, 1862, including the whole literature which it provoked; and O. Lorenz, 'Die Geschichtswissenschaft,' Berlin, 1886, especially the first chapter.

[1] On the Critical school of philology, and the wider and narrower sense in which the aims and methods of the science of antiquity were defined, see Bursian, 'Geschichte der classischen Philologie in Deutschland,' Munchen und Leipzig, 1883, p 665, &c.; also O. Ribbeck, 'Friedrich Ritschl,' Leipzig, 1879 and 1880 Further, the essays on Bockh, K. O Muller, and Georg Curtius in the third volume of Ernst Curtius, 'Alterthum und Gegenwart,' Berlin, 1889; and, finally, the chapter on "Klassische Philologie" by Wilamowitz-Mollendorf in Lexis, 'Die deutschen Universitaten,' vol. i. p 457, &c

[2] Alexander von Humboldt (1769-1859) published in 1797, shortly after Galvani's great discovery, his 'Versuche uber die gereizte Muskel- und Nervenfaser.' In the history of science his name will live as that of the man who organised that "scientific conspiracy of nations" which is peculiar to our century, and without which the study of geography, meteorology, astronomy, the phenomena of tides and magnetic disturbances—called by him magnetic storms—could not effectually be carried on The fact also that on his return from his great travels he became next to Napoleon Bonaparte the most famous man in Europe, did more than anything else to raise the natural sciences in the popular mind to that eminence which earlier belonged to polite literature.

fore he left Germany for the extensive travels by which he became celebrated, and through which he founded a new science—the science that deals with the geographical distribution of plant life. Moreover, his absence from his native country fell within that period during which the philosophical school, headed by Schelling and Hegel, attained to its greatest power. He was never drawn into its vortex; on the contrary, he maintained a lifelong protest against the spirit of its doctrine at a time when the circle which surrounded him at Berlin came under its powerful influence.[1] He led a long line of ardent young workers both to the right sources of scientific knowledge and to an ultimate victory over the opposed school of thought. Though not a profound mathematician himself, he appreciated the part which mathematics were destined to play in science. Among other things, he protected and encouraged younger mathematical talents, and tried to draw Gauss from the solitary heights which he inhabited into the midst of the scientific circles of the day.[2] Then there was the great influence which

[1] Cf p. 178, note 1. It has latterly become the fashion to say so much against the mistaken methods of the *Naturphilosophie* that it is well to remember how many men of foremost rank in the natural sciences belonged at one time to this school or were influenced by it Foremost of all stands Oken (1779-1851), the founder of the German Association of Science, and editor of the periodical 'Isis.' Further, the comparative anatomist Carus (1789-1869); Oersted (1777-1851), the discoverer of electro-magnetism, Kielmeyer, the friend of Cuvier (1765-1844), Ignaz Dollinger (1770-1841), one of the earliest evolutionists; D. G. Kieser (1779-1862), a medical teacher of great influence More or less influenced by the teachings of this school were Goethe (1749-1832); Karl Ernst von Baer (1792-1876), whose impartial opinion on the *Naturphilosophie* as early as 1821 is important Further, Liebig (1803-73), Johannes Muller (1801-58); Roschlaub (1768-1835); Schonlein (1793-1864), the founder of what is called the "natural-history" school of medicine.

[2] See A. von Humboldt's Life by Bruhns, translated by Lassell, 1873, vol. ii. p. 145 *sqq*.

80. Influence of Berzelius on German science.

Berzelius exerted on German science through his teaching and his writings. From him emanated that great perfection of the purely experimental methods which in his own hands, as well as in those of Wohler, Mitscherlich, Magnus, and others, led to an accumulation of detailed knowledge in chemistry of unforeseen importance and magnitude. His own annual reports, as well as Gmelin's celebrated handbook of chemistry, are monuments of this unparalleled industry.

Others, like Liebig, Johannes Muller, Lucas Schönlein, freed themselves under the influence of French science,[1] or by their own deeper insight, from the sway of the false and misleading philosophy to which they had at one time listened. A third section started from philosophical premisses, but from premisses opposed to the doctrines of Schelling and Hegel.

The school of Fries,[2] in which Schleiden was the most

[1] English science had an important but less marked influence on the development of naturalistic and medical studies in Germany. So far as the latter especially are concerned, see Billroth, 'Ueber das Lehren und Lernen der medicinischen Wissenschaften an den Universitaten der deutschen Nation,' Wien, 1876, p. 33 He roughly divides the medical schools of Germany into two groups, both descending from Boerhaave · the one, the modern Berlin school of Muller, Schonlein, Romberg, and Virchow, through Haller, Reil, Hufeland, and Roschlaub; the other, the modern Vienna school of Oppolzer, Rokitansky, and Billroth, through Gerhard von Swieten, De Haen, Stoll, Frank, Purkinje, and Skoda. Of French names which had great influence he gives Broussais, Corvisart, Bayle, Cruveilhier, and Laennec, of English, John Hunter, Matthew Baillie, and Astley Cooper. He gives also the name of Immanuel Kant as an important influence in the development of the German schools of medicine.

[2] Jacob Fries (1773-1843) professor at Heidelberg and Jena, led the critical philosophy of Kant into the channels of psychology and anthropology. During the heyday of transcendental philosophy, the philosophy of Fries, like that of the Scotch school, was regarded with contempt by Hegel, and even by Herbart, the opponent of Hegel. It succeeded, however, in the end in influencing a considerable number of philosophical minds, who carried philosophical thought into the inductive sciences. Besides the psy-

illustrious name, carried on within the pale of the philosophical school of science itself a successful opposition to the philosophy of Nature.[1] But whilst much good and sound work was done by many who were content to remain outside of the favoured studies which set the tone of university culture during the classical and philosophical period of German thought, the great attack upon the mistaken canons of the philosophy of Nature came from that science which had probably suffered more than any other under the baneful influence of hollow theories and empty phraseology.

31 Philosophy of Nature and medical science.

Helmholtz describes the despair which had taken hold of thinking minds in the medical profession[2]: "My education fell within a period of the development of medicine when among thinking and conscientious minds there reigned perfect despair It was not difficult to understand that the older and mostly theorising methods of treating medical subjects had become absolutely useless. But with the theories the facts which underlay them were so indissolubly entangled that these two were mostly cast overboard. How the science must be newly built up the example of the other natural sciences had made clear, but yet the new task stood of giant-height before us. A beginning was hardly made, and the first beginnings were

chologist Beneke and the theologian De Wette, these were principally members of the Jena school, Apelt, Schlomilch, and others, who edited 'Abhandlungen der Fries'schen Schule,' Jena, 1847; and foremost among them Schleiden, the reformer of botany in Germany Schleiden's great work appeared with the title 'Botanik als inductive Wissenschaft' It opened with a philosophical introduction of 131 pages, in which inductive reasoning is recommended in opposition at once to the transcendental *Naturphilosophie*, and to dry empiricism. See Sachs, 'Geschichte der Botanik,' p 203, &c

[1] See Schleiden, 'Schelling's und Hegel's Verhaltniss zur Naturwissenschaft,' Leipzig, 1844

[2] See Helmholtz, 'Vortrage und Reden,' vol. i. p. 361.

often very crude. We cannot wonder if many honest, serious, thinking men then turned away in dissatisfaction from medicine, or if they from principle embraced an extreme empiricism"[1] "But the right kind of work brought forth its fruits much sooner than many had hoped. The introduction of mechanical notions into the theories of circulation and respiration, a better insight into the phenomena of heat, the more minutely elaborated physiology of the nerves, speedily produced practical results of the greatest importance, the microscopical examination of parasitic tissues, the stupendous development of pathological anatomy, led irresistibly from nebulous theories to real facts." And again[2]: "Whilst in the investigation of inorganic nature the different nations of Europe progressed pretty evenly, the recent development of physiology and medicine belongs pre-eminently to Germany. The questions regarding the principle of life

[1] Cf. Helmholtz, ibid., vol ii p 178, in his discourse "Ueber das Denken in der Medicin" "At that time there were many among the younger doctors who, in despair about their science, gave up all therapeutics, and took to empiricism, such as was then taught by Rademacher. This on principle regarded as vain all hope of scientific insight" Not only the extreme empiricism of Rademacher (1772-1850), but still more the wild theories of Hahnemann (1755-1843) found during this age of general unsettlement many followers See on the origin, the principles, and the spread of homœopathy, Haser, 'Geschichte der Medicin,' vol. ii. p 793, &c Haser gives the year 1816 as the date at which Hahnemann's doctrines began to be accepted in wider circles. "It must not be forgotten that the heyday of homœopathy fell in that age when medicine, especially in Germany, was in a very deficient state, so that the accusations raised by Hahnemann and his adherents did not appear quite unfounded. It is even to be admitted that homœopathy has contributed to the reaction through which in our times the regeneration of the art of healing has been brought about, though this would have taken place without Hahnemann" (p 803) Homœopathy has no scientific representative at any of the German universities, and yet it is admitted that it "still enjoys a great reputation in some influential circles among the general public" (Hirsch, 'Gesch d. medicinischen Wissenschaften,' p 570).

[2] Helmholtz, *loc. cit.*, vol. i p 362.

are closely allied to psychological and ethical questions. To start with, here also that untiring industry is required which applies itself to pure science for purely ideal purposes, without immediate prospects of practical usefulness. And indeed we may glory in the fact that in this German scholars have always distinguished themselves by their enthusiastic and self-renouncing diligence, which labours for inner satisfaction and not for outer success."

32 Science for its own sake.

This habit of self-renouncing labour, of singleness of purpose—in short, the ideal of pure science and its pursuit—had been elaborated in many a secluded workshop of a retired German university mainly under the influence of the classical and philosophical studies of the end of the last and the beginning of the present century. It was held up high and conspicuous by the priests of humanity, beginning with Lessing, Herder, and Kant, and ending in Schleiermacher, Hermann, and Bockh, at the head of a great army of devoted followers, travelling through the wilderness of national depression, barbarism, and despair into the promised land of freedom, culture, and hope. Such an ideal is of priceless worth, and it is this ideal which the philosophical and classical school of thought bequeathed during the first half of the century to that new school of thinkers which was destined to study, in an equally patient and unselfish spirit, the seemingly less elevated, but not less mysterious and fascinating, problems of Nature. Truly Gauss, Weber, and Johannes Muller worthily headed the new army of labourers.

33. Bequest of the classical and philosophical school.

But though the elevated spirit in which scientific work is carried on may be the most valuable bequest of the classical and philosophical to the exact and empirical

school, there were certain more tangible characteristics of German research, which were carried over from the older to the modern type of thought. It will be useful to define these more clearly.

In the course of the second half of the eighteenth century German literature and German philosophy had started from the beginnings laid by other nations, and after mastering and appropriating their achievements, had set out for a new course and a higher flight. Milton and Shakespeare[1] in epic and dramatic poetry; Ossian, the Percy Ballads, and Burns in song and lyric; Gibbon in history; Joseph Scaliger and Bentley in philology; Locke, Hume, and Spinoza in philosophy; Rousseau in prose,—all these great names of a later or earlier past had become familiar watchwords to German poets or students—to Lessing, Herder, and Goethe, to Schlegel, F. A. Wolf, and Wilhelm von Humboldt, to Böckh, Hermann, and Niebuhr, to Kant, Fichte, and Jacobi, before they came forward with their own creations. The same cosmopolitan spirit of looking elsewhere and everywhere for beginnings, and for co-operation in the united work of learning; the same historical taste, the same desire to glean from all quarters,—characterised the early decades of the revival of German science. Hence the many periodicals and annual reports, hence the fact that the

[1] These names are not given as they follow in time, but as they followed in their influence on German thought and literature Thus the early representatives of the German revival were influenced by Milton and Pope more than by the greater Shakespeare: epic and didactic preceded dramatic poetry: Shakespeare was made familiar to German readers only through Goethe and Schlegel. Similarly the reaction against the school of Leibniz and Wolff in philosophy began with Kant's reply to Hume's sceptical philosophy, whereas the study of Spinoza influenced Kant's followers and opponents, Jacobi, Fichte, and Schelling.

nation which requires them least[1] possesses the most and the best translations of foreign authors. But the quality of greatest value for science which springs from the cosmopolitan and historical spirit is that of completeness and thoroughness of research.

34. Completeness and thoroughness of research

Secondly, the German man of science was not only thorough, but was as little as the German philosopher or classicist had been, an isolated thinker. He was neither the member of an academy only, nor a solitary genius reduced to the resources of his own study. He lived mostly at a university, surrounded by others, whose labours came in contact with his own, or who treated the same subject from a different point of view. He had thus to define the limits of his science, and to see that no part of the common field was left uncultivated and unexplored. His object could not be to produce simply a work of individual greatness or of finished artistic merit; his work was an integral portion of the one great science; his

[1] This must not be misunderstood. A knowledge of the masterpieces of foreign literature was as necessary to the development of the German mind as it is to that of any other nation; it was and is more complete there than in any other country. what I mean is, that as a knowledge of French and English has been for a long time so common among the educated classes in Germany, translations are more easily dispensed with there than in other countries In spite of that, German literature abounds in excellent translations of the classics of France and England both in general literature and in science. It is also interesting to note that no modern language has succeeded so well in imitating foreign and classical metres as the German, hexameters having become domiciled in Germany through Voss and Goethe, the Alcaic and Sapphic metres through Klopstock and Herder, the more complicated stanzas through Platen, and above all through Donner's excellent renderings of the Greek dramatists. Ruckert excelled in the imitation and reproduction of Persian, Indian, and Arabic poetry, and through him and Friedrich Bodenstedt German literature has been enriched by many lines of which it would be difficult to say whether their home was in Germany or in the far East, so perfectly is the spirit and diction reproduced. The well-known 'Weisheit des Brahmanen' of Ruckert, and Bodenstedt's 'Mirza Schaffy' are examples.

labours had to fit in with the general plan, to find a place in the one great edifice.

85 Combination of research and teaching.

Thirdly, the German man of science was a teacher; he had to communicate his ideas to younger minds, to make the principles and methods of research clear, to guarantee, in his course of lectures, something like completeness, to give a comprehensive survey; not to teach "une science faite," but to draw out original talent in others, to encourage co-operation in research, to portion out the common work to the talents which surrounded him, or it might be to direct the flight of the aspiring genius.[1]

[1] Here the two main objects of academic teaching are to impart a knowledge of the right method in the special science, and to give a survey of the whole domain of the science. The two principal institutions by which these objects are attained were first set going in the classical branches of study, and may be defined by two terms—the "seminary" and the lecture on "encyclopædia." Both terms are taken from earlier institutions. The seminary was originally a training-school for priests or teachers. Under such masters of methodical research as F. A. Wolf and Gottfried Hermann, the institution acquired a different character. "The seminaries are the real nurseries of scientific research. They were founded, indeed, with a different object; the first seminaries, the philological seminaries, which were started during the last century at Halle and Gottingen, were or should have been pedagogic seminaries for the future masters in the learned schools. In reality they were—especially that of F. A. Wolf—in the first place institutions in which the art of philological research was taught. This is even more the case in the philological seminaries and societies which during the nineteenth century have been conducted by G. Hermann, Fr. Thiersch, Fr. Ritschl, and others: they were nurseries of philologists, not of teachers. And the same may be said of the numerous seminaries which in modern times have grown up in the other sciences within the philosophical faculty, and also in the faculties of theology and law: they set up as their aim—with few exceptions—the training for scientific work and research, not the utilisation of knowledge for a practical purpose" (Paulsen in Lexis, 'Die deutschen Universitaten,' vol i. p. 74, &c.) The same idea was in the mind of Liebig when he started the first chemical laboratory at Giessen (see *supra*, p. 188, note). The encyclopædic treatment of every large subject in a special course of lectures arranged for this purpose had the object of preventing the different studies from falling asunder or ultimately failing to unite in the realisation of one great aim. This great aim of all philological studies, for instance, was always held up by men like Wolf, Hermann, Bockh, and Ritschl, among

Lastly, the German man of science was a philosopher. Whatever his aversion might be to special philosophical doctrines, he had generally come under the influence of some philosophical school, the teaching of which he desired either to uphold or to combat. Sooner or later, consciously or unconsciously, he had to make clear to himself and to his disciples the underlying principles which he thought the right ones, to defend them against attacks from others, or to modify them, as progressing research made it necessary. If the historical sciences had benefited most by the philosophy of Schelling and Hegel, which attempted to give new and constructive views on the intellectual and ethical manifestations of the human or the general soul, the mathematical and phy-

36 Combination of science and philosophy.

whose favourite lectures were those on "encyclopædia" of philology. Something similar existed, and exists still, in theology, law, and what are called "*Staatswissenschaften*" All these terms are supposed to embrace a variety of studies which are organically combined in one whole, forming a cycle. In philosophy proper Hegel, and later Lotze, delivered well-known and largely attended lectures under the title of Encyclopædia. This is a remnant of the encyclopædic or organic treatment of knowledge sketched out by Bacon, and proposed as a basis for their celebrated work by Diderot and D'Alembert (see *ante*, p. 35 and note). The encyclopædia, as a learned dictionary, we have seen, has since become merely a synopsis. How different from this was the truly encyclopædic treatment given by men like Bockh can be seen from his correspondence with K. O. Muller, where he scolds his younger friend for undertaking to write the article "Topography of Athens" for "such a cursed publication as an encyclopædia," whereas he himself was regularly lecturing on "encyclopædia of philology," in which he took in earnest the idea of classical philology as "the historical science of the life of the ancient peoples" (see Curtius, 'Alterthum und Gegenwart,' vol iii. p. 138, &c.) Now although the exact sciences when they became domiciled in the German universities did not in general copy this institution, yet the historical and philosophical survey, giving method and unity to a large circle of studies, has been upheld by many among the foremost men of science, especially in the medical faculty. Of these I only mention Joh. Muller (see Du Bois-Reymond, 'Reden,' vol ii. pp 195, 279) and his pupil and follower Jacob Henle, who in his lectures on anthropology took a philosophical survey of the whole subject of the medical studies (see 'Jacob Henle' by Merkel, p. 271, &c)

sical sciences have been most affected by the spirit of Kant's philosophy, which has ineradicably engrained in the German mind the necessity of a criticism of the principles of knowledge. Ever and anon some of the most brilliant intellects in mathematics and science have reverted to the same problems, and, on the whole, they have confirmed the position taken up by Kant a century ago.

It was thus under the influence of the exact methods of experiment and calculation taught by the great French school in the beginning of the century, and at the same time through the philosophical spirit peculiar to German science, that in the middle of the century the different sciences which deal with the phenomena of life and consciousness were remodelled. The great science of biology, based upon mechanical principles, was thus created, and the results gained in it brilliantly applied to the reorganisation of the medical profession. But this great reform does not belong exclusively to one great name; it is the work of a long line of thinkers: nor can I conceive that the exclusive employment of the methods of exact research would have so effectually brought it about, unaided by the philosophical, historical, and critical spirit which formed the peculiar characteristic of German thought before the exact methods had been generally introduced. And just because this reform required to be effected from so many different beginnings, and gradually elaborated and defended before it became firmly established, do the modern sciences of physiology and pathology deserve to be termed pre-eminently German sciences; for no other

137. Biology grown out of science and philosophy combined.

country possessed the necessary conditions and extensive organisations, the habits of combined study and patient co-operation, the large views and the high aims, which had been acquired at the German universities under the guidance of the German ideal of *Wissenschaft*, and under the sway of the philosophical and classical spirit.

A great authority,[1] who as much as any one represents the modern as distinguished from the earlier views in biological science, reviewing the different agencies which have brought about the great change, speaks thus. He is referring to Johannes Muller, the father of modern physiology. "The modern physiological school," he says, "with Schwann at its head, has drawn the conclusions for which Muller had furnished the premises. It has herein been essentially aided by three achievements which Muller witnessed at an age when deeply-seated convictions are not easily abandoned. I mean, first of all, Schleiden and Schwann's discovery, that bodies of both animals and plants are composed of structures which develop independently, though according to a common principle. This conception dispelled from the region of plant-life the idea of a governing entelechy, as Muller conceived it, and pointed from afar to the possibility of an explanation of these processes by means of the general properties of matter. I refer, secondly, to the more intimate knowledge of the action of nerves and muscles, which began with Schwann's researches, in which he showed how the force of the muscle changes with its contraction. Investigations which were carried on with all the resources

38 Du Bois-Reymond on Muller.

[1] See Du Bois-Reymond, 'Reden,' vol ii. p. 219, &c

of modern physics regarding the phenomena of animal movements, gradually substituted for the miracles of the 'vital forces' a molecular mechanism, complicated, indeed, and likely to baffle our efforts for a long time to come, but intelligible, nevertheless, as a mechanism. The third achievement to which I refer is the revival among us by Helmholtz and Mayer of the doctrine of the conservation of force. This cleared up the conception of force in general, and in particular supplied the key to a knowledge of the change of matter in plants and animals. By this an insight was gained into the truth that the power with which we move our own limbs (as George Stephenson did those of his locomotive) is nothing more than sunlight transformed in the organism of the plant: that the highly oxygenated excrements of the animal organism produce this force during their combustion, and along with it the animal warmth, the πνεῦμα of the ancients. In the daylight which through such knowledge penetrated into the chemical mechanism of plants and animals, the pale spectre of a vital force could no more be seen. Liebig, indeed, who himself stood up so firmly for the chemical origin of animal heat and motive power, still retains an accompanying vital force. But this contradiction is probably to be traced to the circumstance that the celebrated chemist came late, and as it were from outside, to the study of the phenomena of life. And even Wöhler still believes in a vital force, he who in his time did more than any one to disturb the vitalistic hypothesis through his artificial production of urea."

89. "Vital force" abandoned

It was a process of critical sifting similar to that which Kant[1] applied to our general metaphysical ideas, which in the middle of the century, through the writings of Berzelius and Liebig, of Schwann and Schleiden, of Henle, Lotze, and Du Bois-Reymond, gradually dispelled the older confused notions, and firmly established the mechanical view in the study of the phenomena of life. But as we are forced to recognise the substance of much of Kant's philosophical criticism in the lucid expositions of Locke and Hume before him, so it has been pointed out that the words of the eminent French physiologist, Vicq-d'Azyr, contain the substance of the more modern ideas on life.[2] It required the co-operation of the exact

40 Mechanical view in biology.

[1] The great influence which belongs to Kant in the development of modern German science has been frequently dwelt on In more recent times some of the first representatives of the medical and biological sciences have dealt with the subject, and the opposition which fifty years ago originated in the extravagances of some of Kant's successors, has given way to a renewed recognition of the just claims of Kant We may refer to Du Bois-Reymond, who, forgetting Lotze, calls Kant the last philosopher who took a part in the work of the naturalist ('Reden,' vol i p 33), to Helmholtz, who in many passages of his popular addresses refers to the merits of Kant ('Vortrage und Reden,' 1884, vol. i. pp 44, 368, ii 58, 227, 234, 248, &c), to Haeser ('Geschichte der Medizin,' vol ii. p. 811). I will add to these the opinion of so great an authority as Prof. Billroth of Vienna, who, speaking of the two modern schools of medicine in Germany, says ('Lehren und Lernen der medicinischen Wissenschaften,' &c, p 334): "However great the degree of independence may be which the two parallel schools have attained, they would hardly have developed so rapidly without the powerful influence which came from France and in a lesser degree from England; nor yet without that of Immanuel Kant, who in his 'Autophysiology of Reason' enlightened German minds regarding their own selves, and who with his lively imagination fervently embraced natural science"

[2] The remarkable passage referred to is quoted by Du Bois-Reymond ('Reden,' vol. ii p 27): "Quelqu' étonnantes qu'elles nous paraissent, ces fonctions (*viz*, dans les corps organisés) ne sont-elles pas des effets physiques plus ou moins composés, dont nous devons examiner la nature par tous les moyens que nous fournissent l'observation et l'expérience, et non leur supposer des principes sur lesquels l'esprit se repose, et croit

spirit of research with the critical methods acquired in the school of philosophy, and the exhaustive survey of a large array of facts acquired through historical and classical studies, before the significance of this brilliant *aperçu* became evident; before the underlying ideas could become useful guides of research and progress. "Tantæ molis erat Romanam condere gentem."

Though the reform of the biological [1] sciences, and their application to pathological inquiries, are probably the greatest achievement which the methods of exact research, in conjunction with the philosophical spirit, can boast of in Germany in the century, the same habit

avoir tout fait lorsqu'il lui reste tout à faire" This was said at the end of the last century, and fifty years later Du Bois-Reymond (*loc cit*) could complain that the truth contained in these words was not yet generally admitted, in spite of the labours of Berzelius, Schwann, Schleiden, and Lotze. Compare also A. von Humboldt's own confessions on this point in his 'Ansichten der Natur,' vol. ii. p. 309, &c, edition of 1849.

[1] I must remind the reader here that though I use the word biological as denoting the more recent point of view from which all phenomena of the living world are being grouped and comprehended, and though the word seems to have been first used by a German, nevertheless the arrangement of studies at the German universities has hardly yet recognised the essential unity of all biological sciences. They are unfortunately still divided between the philosophical and the medical faculties. It is indeed an anomaly, hardly consistent with the philosophical and encyclopædic character of German research, that palæontology, botany, zoology, and anthropology should belong to the philosophical, whereas anatomy, physiology, and pathology are placed in the medical faculty. Eminent biologists and anthropologists, such as Schleiden, Lotze, Helmholtz, and Wundt, have accordingly belonged to both faculties. To place biological studies on the right footing would require a mind similar to that of F A. Wolf, who evolved out of the vaguer idea of *humaniora* the clearer notion of a "science of antiquity," and who accordingly was able to convert the training-school of teachers, the seminary, into a nursery of students of antiquity Whether a similar reform in the purely scientific interests of the "science of life," which is now mostly cultivated for the benefit of the medical practitioner, can be effected in this age, when practical aims are gradually taking the place of scientific ideas, is another question.

of thought has shown itself in other fields of research, and led to similar innovations. I will here only mention one other line of inquiry, where neither exact nor metaphysical reasoning alone suffices, but where a combination of both is essential. I mean the gradual change which, mainly through the writings of German mathematicians, has come over our fundamental conceptions in the region of geometry, algebra, and the theory of numbers. This subject belongs so essentially to the domain of pure thought that a history of thought seems specially called upon to take notice of it. Accordingly I intend to devote a special chapter to it. At present it interests us mainly because it is an outcome of that peculiar modification which the exact or scientific spirit of thought underwent when, introduced by French and English models, it came in contact with the philosophical and classical ideal of learning in Germany. I will repeat more clearly and concisely what I mean. The exact methods of thought, mainly elaborated in France, and there largely applied, give to science its accuracy and definiteness. In spite of this accuracy and definiteness, it is not immediately clear whether they will lead to completeness of knowledge, or whether they may not be misapplied. To guarantee completeness, to make sure that in the whole great field no portion has remained untouched and unexplored, that love of detail, that searching and exploring spirit, is required which is nursed pre-eminently by historical and classical studies. And to avoid the abuse of existing methods, there is further required that critical spirit which inquires into the value of principles

41. Criticism of principles of mathematics

and the limit of their usefulness. These three directions of thought mark three tolerably distinct attitudes of the human mind. Skill in inventing and in applying new and precise methods—the exact habit or attitude of thought; love of detail, and the desire for complete and exhaustive knowledge—the historical habit or attitude of thought, lastly, the desire to become fully alive to the value of existing methods or principles, which implies a consciousness of the limited nature of one and every principle—the critical habit or attitude of thought. The progress of mathematics and natural science depends primarily on the first; classical studies depend on the second; philosophical reasoning mainly on the last. Each of the three nations which have led human progress and thought during the past centuries has probably been possessed of these three cardinal virtues in equal proportions. For though Newton stands pre-eminent in the first, we have Laplace and Gauss and their numerous followers in other countries; though the great volume of classical learning and criticism has emanated from the schools of Wolf, Hermann, and Böckh, they themselves point back to Bentley and Joseph Scaliger; and even Kant's unrivalled enterprise was prepared by Hume, and dates back to Descartes. There need, therefore, be no angry rivalry or carping jealousy. We may point to the remarkably equal contributions of the three nations to the general progress of thought. But a very different and truly legitimate interest prompts us to note how in the great performances of each nation, in the literature of each of the three languages, different factors have been at work—different

42 The exact, the historical, and the critical habits of thought

agencies have combined to produce the effect. In this regard the spectacles presented by French, German, and English thought differ. And there seems to me little doubt that during a considerable portion of this century the German universities, grown out of theological, legal, and medical studies, and widening gradually till they embraced and deepened all three by the philosophical, the classical, and the exact spirit of research, present that organisation in which the different elements of thought are most equally balanced, through which modern knowledge and the scientific spirit have been most widely and successfully diffused, and that the German ideal of *Wissenschaft* embraces at once the highest aims of the exact, the historical, and the philosophical lines of thought.

43. Combined in the German ideal of *Wissenschaft*

Nor would it be right to pass from the consideration of this peculiar feature of nineteenth-century thought, which is an outcome of the German university system, without noticing the moral significance which this ideal of *Wissenschaft* acquired, and which marks it as a factor in progress and in culture of much more importance even than the lasting discoveries in science which it has made, or the monuments of learning which it has reared. It is not the political side of this movement which I refer to, not even pre-eminently the educational, though these are interesting and important enough to demand special historical treatment. What I should like to point to as the greatest in this movement is, that it belongs to the few and rare instances in the history of mankind when we see a large number of the most highly gifted members of

44. Moral value of *Wissenschaft*

a nation following a purely ideal cause, apart from the inducements which gain or glory may furnish. The pursuit of truth and the acquisition of knowledge for its own sake, as an ennobling and worthy occupation, has during a large portion of our century been the life-work of professors and students alike in the German universities. In the biographies of many of them we meet with that self-denial and elevation of spirit which is the true characteristic of every unselfish human effort. In perusing these records of high aspirations, arising frequently amid disheartening surroundings, these stories of privations cheerfully endured, of devotion to an ideal cause, glowing with all the fervour of a religious duty, we gain a similar impression to that which the contemplation of the Classical period of Greek art or the early Renaissance produces on our mind.

Once at least has science, the pursuit of pure truth and knowledge, been able to raise a large portion of mankind out of the lower region of earthly existence into an ideal atmosphere, and to furnish an additional proof of the belief that there, and not here below, lies our true home. We may perhaps have to admit with regret that this phase is passing away under the influence of the utilitarian demands of the present day; we may be forced to think that another—and, we trust, not a lower—ideal is held up before our eyes for this and the coming age. But no really unselfish effort can perish, and whatever the duty of the future may be, it will have to count among the greatest bequests of the immediate past that high and broad ideal of science which the life of the Ger-

nan universities has traced in clear and indestructible outlines.[1]

[1] The testimonies by illustrious foreigners to the great work of the German universities are frequent and well known, from the time when Mme. de Staël visited Germany, and her friend Villers wrote his 'Coup-d'œil sur les Universités d'Allemagne' in 1808, through the writings of Cousin, the verdict of Renan, of Cournot, of Dreyfus-Brisac, and of the American, J. M. Hart To these often-repeated expressions I will add that of the great apostle of higher culture of our age, of Matthew Arnold, who sums up his interesting report on the German system of higher education in these characteristic words: "What I admire in Germany is, that while there, too, Industrialism, that great modern power, is making at Berlin and Leipzig and Elberfeld most successful and rapid progress, the idea of Culture, Culture of the only true sort, is in Germany a living power also. Petty towns have a university whose teaching is famous through Europe; and the King of Prussia and Count Bismarck resist the loss of a great savant from Prussia as they would resist a political check. If true culture ever becomes at last a civilising power in the world, and is not overlaid by fanaticism, by industrialism, or by frivolous pleasure-seeking, it will be to the faith and zeal of this homely and much-ridiculed German people that the great result will be mainly owing" ('Schools and Universities on the Continent,' 1868, p. 256).